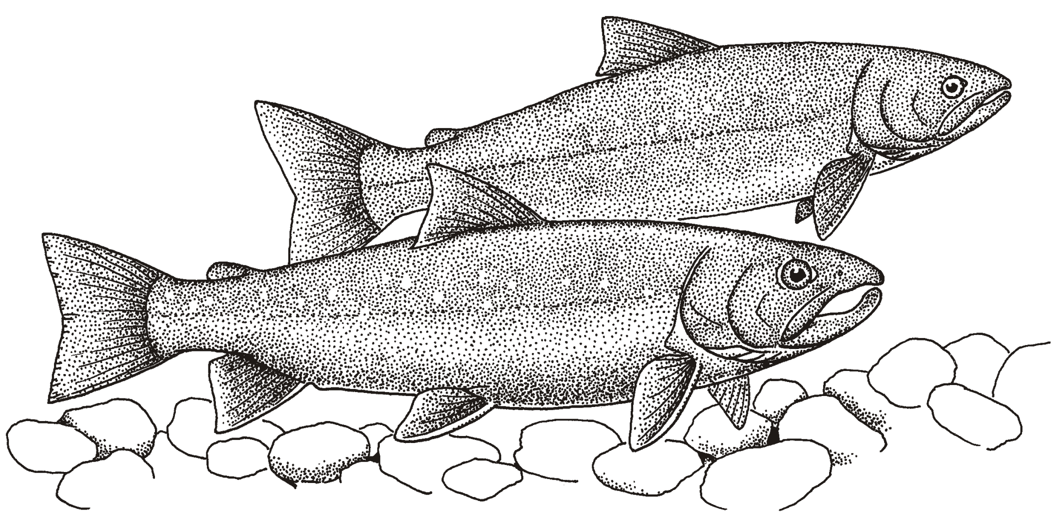
U.S. Fish & Wildlife Service

Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*)

Volume I (of II)
Puget Sound Management Unit

(including the Chilliwack River and associated tributaries flowing into British Columbia, Canada)



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(May 2004)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Regional Director, U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recover and/or protect the species. Recovery plans are prepared by the U.S. Fish and Wildlife Service and, in this case, with the assistance of recovery teams, State and Tribal agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views or the official positions or indicate the approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service *only* after they have been signed by the Director or Regional Director as *approved*. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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Electronic copies of this recovery plan are available at:
<http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm> and also at <http://endangered.fws.gov/recovery/index.html>.

Note to readers: A glossary of technical terms is provided in Appendix 5 of this plan. Terms provided in the glossary are denoted with a superscript symbol (†) the first time they appear in the plan.

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EXECUTIVE SUMMARY

The Puget Sound Management Unit is one of two management units† comprising the Coastal-Puget Sound Distinct Population Segment† of bull trout (*Salvelinus confluentus*). The overall recovery implementation strategy for the Coastal-Puget Sound Distinct Population Segment is to integrate with ongoing Tribal, State, local, and Federal management and partnership efforts at the watershed† or regional scales. This coordination will maximize the opportunity for complementary actions, eliminate redundancy, and make the best use of available resources for bull trout and salmon recovery.

Current Species Status

The U.S. Fish and Wildlife Service issued a final rule listing the Coastal-Puget Sound and St. Mary-Belly River Distinct Population Segments of bull trout as threatened on November 1, 1999 (64 FR 58910). This final rule resulted in all bull trout within the coterminous United States being listed as threatened, as three additional distinct population segments had earlier been listed separately (the Klamath River, Columbia River, and Jarbidge River Distinct Population Segments; 63 FR 31647, 64 FR 17110). As provided in the final listing rule, however, we are continuing to refer to the original distinct population segments for the purposes of recovery planning and consultation (64 FR 58910). The Coastal-Puget Sound Distinct Population Segment is significant to the species as a whole because it contains the only anadromous† forms of bull trout in the coterminous United States, thus, occurring in a unique ecological setting. Also unique to this population segment is the overlap in distribution with Dolly Varden, another native char† species extremely similar in appearance to bull trout, but distinct genetically.

The Puget Sound Management Unit includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound. This management unit also includes the Chilliwack River watershed, a transboundary system flowing into British Columbia and discharging into the Fraser River. Bull trout are distributed throughout most of the major watersheds and associated tributary systems within the Puget Sound Management Unit, and they exhibit anadromous, adfluvial[†], fluvial[†] and resident[†] life history patterns. The Puget Sound Management Unit consists of eight core areas[†] (a core area consists of one or more local populations of bull trout and their habitat), with a total of 57 local populations[†] and 5 potential local populations[†] distributed among the core areas (see Table 5).

Recovery Priority

The recovery priority number for bull trout in the coterminous United States is 9C, on a scale of 1C (highest) to 18 (lowest), indicating: 1) taxonomically, we are treating these populations as distinct population segments of the species; 2) the bull trout is subject to a moderate degree of threat; and 3) the potential for recovery is considered high. The "C" indicates the potential for conflict with human activities during recovery (USFWS 1983a, b).

Habitat Requirements and Limiting Factors

Bull trout have more specific habitat requirements than most other salmonids. Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors[†]. Cold water temperatures play an important role in determining bull trout habitat, as these fish are primarily found in colder streams (below 15 degrees Celsius; 59 degrees Fahrenheit), and spawning habitats are generally characterized by temperatures that drop below 9 degrees Celsius (48 degrees Fahrenheit) in the fall. All life history stages of bull trout are associated with complex forms of cover, including large woody debris[†], undercut banks, boulders, and pools. Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns. Additionally, since bull trout are iteroparous (they survive to spawn year after year) and many populations are migratory, these fish therefore require two-way passage up and downstream, not only for repeat spawning but also for foraging. Therefore even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide adequate two-way passage for subadults and adults.

Within the Puget Sound Management Unit, historical and current land use activities have impacted bull trout. Some of the historical activities, especially water diversions, hydropower development, forestry, agriculture, and urban development within the core areas, may have significantly reduced important anadromous populations. Lasting effects from some of these early land and water developments still act to limit bull trout production in core areas. Threats from current activities are also present in all core areas of the Puget Sound Management Unit. Land and water management activities that depress bull trout populations and degrade habitat in this management unit include some aspects of operation and maintenance of dams and other diversion structures, forest management practices, agriculture practices, road construction and maintenance, and residential development and urbanization. Dams and diversion structures impede or limit migration, entrain† individuals, and impair downstream habitat. Forestry activities impact bull trout through decreased recruitable large woody debris†, increased water temperatures from reduced shading, lack of pools and habitat complexity, and increased sedimentation from timber harvesting on unstable slopes and road construction. Agriculture practices impact bull trout through added inputs of nutrients, pesticides, herbicides, and sediment, reduced riparian† vegetation, decreased recruitable large woody debris, and reduced habitat complexity by diking, stream channelization†, and bank hardening. Road construction and maintenance impact bull trout through added channel constrictions, impassible culverts, bank hardening, sedimentation, reduction in riparian shading, contaminant inputs, and impervious surfaces. Development and urbanization impact bull trout through reduced water quality, changed hydrology, reduced riparian shading, sedimentation, and reduced channel complexity from increased bank hardening and channel constrictions. The presence of nonnative species† such as brook trout continue to pose a threat through competition, hybridization†, and potential predation in some core areas.

Recovery Strategy

Presently bull trout are listed as threatened across their range within the lower 48 states (64 FR 58910). Prior to the coterminous listing, five distinct population segments of bull trout were identified. Although these bull trout population segments are disjunct and geographically isolated from one another, they include the entire distribution of bull trout within the United States, therefore a coterminous listing was found to be appropriate in accordance with our policy on the designation of distinct population segments (61 FR 4722). As provided in the final listing rule, we are continuing to use the term “distinct population segments” for the purposes of recovery planning and consultation (64 FR 58910).

A delisting determination can only be made on a “listable entity” under the Endangered Species Act (Act). Listable entities include species, subspecies, or distinct population segments of vertebrate animals, as defined by the Act and U.S. Fish and Wildlife Service Policy (61 FR 4722). Because bull trout were listed at the coterminous level in 1999, currently delisting can only occur at the coterminous level (64 FR 58910). In the future, if warranted by additional information, and if the Coastal-Puget Sound population is reconfirmed as meeting the definition of a distinct population segment under a regulatory rulemaking, delisting may be considered separately for the Coastal-Puget Sound Distinct Population Segment of bull trout once it has achieved a recovered state (61 FR 4722).

The recovery of the Coastal-Puget Sound Distinct Population Segment of bull trout will depend upon the achievement of recovery goals and criteria for the entire distinct population segment. Maintenance of fully functioning core areas across the range of bull trout within the population segment will require that each of the two management units that comprise this distinct population segment contribute to the success of this effort. In keeping with the goal of fostering effective management and recovery of bull trout at the local level, we have developed separate recovery plans for each of these management units, and established specific “recovery targets” for each management unit that will be used to guide bull trout recovery within the distinct population segment as a whole.

Here we define the recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment of bull trout as currently delineated. The site-specific strategies, recovery actions, and recovery targets for the Puget Sound Management Unit are presented in Part II of this plan. The Olympic Peninsula Management Unit is addressed in its own recovery plan.

Recovery Goal for the Coastal-Puget Sound Distinct Population Segment

The goal of this recovery plan is to **ensure the long-term persistence of self-sustaining, complex, interacting groups**[†] **of bull trout distributed across the Coastal-Puget Sound Distinct Population Segment, so that the species can be delisted.**

Recovery Criteria for the Coastal-Puget Sound Distinct Population Segment

The Coastal-Puget Sound Distinct Population Segment will be considered recovered when all core areas are fully functional, as measured by parameters addressing the distribution, abundance, productivity (stable or increasing adult population trend), and connectivity (including the potential for expression of all life history traits) of bull trout. The recovery actions identified in this plan are designed to sufficiently control or eliminate the threats to bull trout such that the recovery criteria may be attained for the Coastal-Puget Sound Distinct Population Segment. The conditions for recovery are identified in the following criteria:

1. The biological and ecological function of the 14 identified core areas (8 in the Puget Sound Management Unit and 6 in the Olympic Peninsula Management Unit) for bull trout within the distinct population segment has been restored. The components of fully functioning core areas include:

a) **Habitat sufficiently maintained or restored to provide for the persistence of broadly distributed local populations supporting the migratory life form within each core area.** The term "broadly distributed" implies that local populations are able to access and are actively using habitat that fully provides for spawning, rearing, foraging, migrating, and overwintering needs at recovered abundance levels. An actual quantitative estimate of the amount of habitat that will be required to meet this criterion is unknown at this time; the adequacy of habitat restoration and management efforts must be measured indirectly by criteria 1b through 1d. The currently identified local populations that will be used as a measure of broad distribution across the distinct population segment are detailed in the recovery targets set for each of the two management units.

b) **Adult bull trout are sufficiently abundant to provide for the persistence and viability of core areas; this level of abundance is estimated to be 16,500 adult bull trout across all core areas.** Resident life history forms are not included in this estimate, but are considered a research need. As more data is collected, recovered population estimates will be revised to more accurately reflect both the migratory and resident life history components. The recovery team[†] has initially set abundance targets conservatively if there was limited available information for constituent core areas; these will likely be revised as new information becomes available. The recovered abundance levels for the currently identified core areas in the distinct population segment are detailed in the recovery targets set for each of the two management units.

c) **Measures of bull trout abundance within all core areas show stable or increasing trends based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data.** Details are provided in the recovery targets for each of the two management units.

d) **Habitat within, and where appropriate, between core areas, is connected so as to provide for the potential of the full expression of migratory behavior (particularly anadromy), allow for the refounding[†] of extirpated populations, and provide for the potential of genetic exchange between populations.** Meeting this criterion requires that passage has been restored or improved, and in some cases further evaluated, at specific barriers identified as inhibiting recovery (including barriers due to physical obstructions, unsuitable habitat, and poor water quality). Known barriers to passage within the Puget Sound Management Unit include the Bellingham Diversion, Gorge Dam, Ross Dam, Tacoma Headworks diversion dam, and Howard Hansen Dam; the Baker River Dams and Electron and Buckley diversions are also in need of passage improvement. Known barriers to passage within the Olympic Peninsula Management Unit include Cushman Dams 1 and 2, Elwha Dam and Glines Canyon Dam, the Washington Department of Fish and Wildlife Dungeness Fish Hatchery, and U.S. Fish and Wildlife Service Quinault National Fish Hatchery. Details regarding these specific barriers are provided in the recovery targets set for each of the two management units.

Meeting this criterion also requires that conditions in both freshwater and nearshore marine foraging, migration, and overwintering habitats[†] are maintained and/or restored to the level that fully support an adequate prey base, especially for the anadromous forms, as well as the other identified components (distribution, abundance, and trend) for fully functional core areas within the Coastal-Puget Sound population segment.

2. A monitoring plan has been developed and is ready for implementation, to cover a minimum of 5 years post-delisting, to ensure the ongoing recovery of the species and the continuing effectiveness of management actions.

<u>Recovery targets for the Puget Sound Management Unit:</u>

1. **Maintain or expand the current distribution of bull trout in the eight identified core areas[1].** The 57 currently identified local populations (Chilliwack (3), Nooksack (10), Lower Skagit (19), Upper Skagit (8), Stillaguamish (4), Snohomish-Skykomish (4), Chester Morse Lake (4), and Puyallup (5)) will be used as a measure of broadly distributed

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[1]This criterion applies only to United States waters within this management unit.

spawning and rearing habitat within these core areas. In addition, distribution within the five identified potential local populations should be confirmed or restored.

2. **Achieve minimum estimated abundance of at least 10,800 adult bull trout spawners among all core areas in the Puget Sound Management Unit. In each of the core areas, the total adult bull trout abundance, distributed among local populations, typically must exceed 1,000 fish.** Recovered abundance targets for the Chilliwack (600), Nooksack (2,000), Lower Skagit (3,800), Upper Skagit (1,400), Stillaguamish (1,000), Snohomish-Skykomish (500), Chester Morse Lake (500), and Puyallup (1,000) core areas were derived using a combination of available data sets, the population guidance discussed earlier, the professional judgement of the recovery team, and estimation of the productive capacity of identified local populations. Resident life history forms are not included in this estimate, but are considered a research need.

3. **Restore adult bull trout to exhibit stable or increasing trends in abundance at or above the recovered abundance target level within the core areas in the Puget Sound Management Unit, based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data. (Note: generation time varies with demographic variables such as age at maturity, fecundity, frequency of spawning, and longevity, but typically falls in the range of 5 to 8 years for a single bull trout generation).**

4. **Restore connectivity by identifying and addressing specific existing and potential barriers to bull trout movement in the Puget Sound Management Unit.** Connectivity criteria will be met when intact migratory corridors are present among all local populations within each core area, thus providing opportunity for genetic exchange and life history diversity. Several man-made barriers to bull trout migration exist within the management unit, and this recovery plan recommends actions to identify, assess, and reduce barriers to bull trout passage. Although

achieving criteria 1 through 3 is expected to depend on providing passage at barriers (including barriers due to physical obstructions, unsuitable habitat, and water quality) throughout all core areas in the management unit, the intent of this criterion is to note specific barriers to correct or actions that must be performed to achieve recovery.

Recovery Actions

Recovery for bull trout will entail reducing threats to the long-term persistence of populations and their habitats, ensuring the security of multiple interacting groups of bull trout, and providing habitat and access to conditions that allow for the expression of various life history forms. Detailed actions specific to this management unit are provided in this plan; in broad terms, these actions include:

1. Protect, restore, and maintain suitable habitat conditions for bull trout.
2. Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout.
3. Establish fisheries management goals and objectives for compatibility with bull trout recovery, and implement practices to achieve goals.
4. Characterize, conserve, and monitor genetic diversity and gene flow among local populations of bull trout.
5. Conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery tasks.
6. Use all available conservation programs and regulations to protect and conserve bull trout and bull trout habitat.
7. Assess the implementation of bull trout recovery by management units and revise management unit plans based on evaluations.

There are a number of research needs that have been identified for this management unit. A high priority goal for the Puget Sound Management Unit is to acquire more complete information on the current distribution and abundance of bull trout within each core area. Additional information is also needed on bull trout use of and distribution in estuarine and marine waters of Puget Sound.

Total Estimated Cost of Recovery

The total cost of bull trout recovery in the Puget Sound Management Unit is estimated at a minimum of $68 million spread over a 25-year recovery timeframe, or an average of approximately $2.7 million per year. The estimate includes recovery actions associated with the Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse, and Puyallup core areas as well as core habitats[†] (including nearshore marine areas) and identified research needs (*e.g.*, upper Green River, upper Nisqually River).

The total cost of bull trout recovery in the Olympic Peninsula Management Unit is estimated at $6.7 million spread over a 25-year recovery period, or an average of approximately $268,000 per year. The estimate includes recovery actions associated with the Skokomish, Dungeness, Elwha, Hoh, Queets, and Quinault core areas as well as core habitats (including nearshore marine areas) and identified research needs (*e.g.*, Satsop River, Hoquiam River).

The total cost of bull trout recovery in the Coastal-Puget Sound Distinct Population Segment is therefore estimated to be approximately $74.7 million over 25 years. If the timeframe for recovery can be reduced, lower estimated costs would occur. Total costs include all funds expended, both public and private, and incorporate estimates of expenditures by local and State governments as well as Federal and private funds. These costs are attributed to bull trout conservation, but other aquatic species will also benefit.

Estimated Date of Recovery

Time required to achieve recovery depends on bull trout status, factors affecting bull trout, implementation and effectiveness of recovery actions, and responses to recovery actions. A tremendous amount of work will be required to restore impaired habitat, reconnect habitat, and eliminate threats from nonnative species. Three to 5 bull trout generations (15 to 25 years), or possibly longer, may be necessary before recovery is achieved.

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PART I. COASTAL-PUGET SOUND DISTINCT POPULATION SEGMENT OF BULL TROUT

INTRODUCTION AND OVERVIEW

Bull trout (*Salvelinus confluentus*), members of the family Salmonidae, are fish native to the Pacific Northwest and western Canada. Trout and salmon relatives in the genus *Salvelinus*, such as bull trout, are often generally referred to as "char[†]." Bull trout occur in five identified distinct population segments[†] within the lower 48 states. In June 1998, we, the U.S. Fish and Wildlife Service, determined threatened status under the Endangered Species Act (16 United States Code [USC] 1531 *et seq*.) for bull trout in two distinct population segments in the Klamath River (Oregon) and Columbia River (Idaho, Montana, Oregon, and Washington) (63 FR 31647). In April 1999, the Jarbidge River Distinct Population Segment of bull trout (Idaho and Nevada) was also determined to be threatened (64 FR 17110). Two more distinct population segments of bull trout, the Coastal-Puget Sound (Washington) and St. Mary-Belly River (Montana), were also found to be threatened in November, 1999 (64 FR 58910). This final listing resulted in all bull trout in the coterminous United States being listed as threatened. However, as provided in the final listing rule, we are continuing to refer to the original distinct population segments for the purposes of recovery planning and consultation (64 FR 58910). This recovery plan addresses the conservation actions deemed necessary for the recovery of the Coastal-Puget Sound Distinct Population Segment of bull trout in the Puget Sound Management Unit[†] (Figure 1; also see "Recovery Plan Terminology and Structure" below).

The recovery priority number for bull trout in the coterminous United States is 9C, on a scale of 1C (highest) to 18 (lowest), indicating: 1) taxonomically, we are treating these populations as distinct population segments of the species; 2) the bull trout is subject to a moderate degree of threat; and 3) the potential for recovery is considered high. The "C" indicates the potential for conflict with human activities during recovery (USFWS 1983a,b).

Figure 1. The Coastal-Puget Sound Distinct Population Segment (DPS) of bull trout, showing the division of the population segment into two management units. The inset map shows the location of the DPS within the State of Washington.

In the interest of streamlining, details regarding the ecology of bull trout in the Coastal-Puget Sound and the threats faced by the bull trout populations there are provided in the listing document for this distinct population segment and are not repeated here (64 FR 58910). However, a brief overview of bull trout life history, habitat needs, and reasons for decline is provided below.

General Description and Life History

Bull trout have been defined as a distinct species (Cavender 1978), however, the genetic relationship among various groups of bull trout within the species can be complex (Rieman and Allendorf 2001). Biologists had previously identified bull trout as Dolly Varden (*Salvelinus malma*), largely because of the external similarity of appearance and the previous unavailability of adequate specimens of both species to any one taxonomist. Morphological (form and structure) analyses have confirmed the distinctiveness of the two species in their different, but overlapping, geographic distributions (Haas and McPhail 1991). Several genetic studies have subsequently confirmed the species distinction of bull trout and Dolly Varden (Phillips *et al.* 1989; Crane *et al.* 1994). Both species occur together in western Washington, for example, with little or no interbreeding (Leary and Allendorf 1997). Lastly, bull trout and Dolly Varden each appear to be more closely related genetically to other species of *Salvelinus* than they are to each other (Phillips *et al.* 1989; Greene *et al.* 1990; Pleyte *et al.* 1992). For example, bull trout are most closely related to Japanese char (*S. leucomaenis*) whereas Dolly Varden are most closely related to Arctic char (*S. alpinus*).

Bull trout exhibit both resident[†] and migratory[†] life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989; Goetz 1989). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial[†] form), river (fluvial[†] form) (Fraley and Shepard 1989; Goetz 1989), or saltwater (anadromous[†]) to rear as subadults or to live as adults

(Cavender 1978; McPhail and Baxter 1996; WDFW *et al.* 1997). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime), and both repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982; Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996).

The iteroparous reproductive system of bull trout has important repercussions for the management of this species. Bull trout require two-way passage up and downstream, not only for repeat spawning but also for foraging. Most fish ladders[†], however, were designed specifically for anadromous semelparous (fishes that spawn once and then die, and therefore require only one-way passage upstream) salmonids[†]. Therefore even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route.

Growth varies depending upon life-history strategy. Resident adults range from 150 to 300 millimeters (6 to 12 inches) total length, and migratory adults commonly reach 600 millimeters (24 inches) or more (Pratt 1985; Goetz 1989). The largest verified bull trout is a 14.6-kilogram (32-pound) specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors[†] (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds[†] must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), fish should not be expected to simultaneously occupy all available habitats (Rieman *et al*.1997).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993; Gilpin, *in litt.* 1997; Rieman et al. 1997). Migrations facilitate gene flow among local populations[†] when individuals from different local populations interbreed, or stray, to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates that there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a very long time (Spruell *et al.* 1999; Rieman and McIntyre 1993).

Cold water temperatures play an important role in determining bull trout habitat, as these fish are primarily found in colder streams (below 15 degrees Celsius; 59 degrees Fahrenheit), and spawning habitats are generally characterized by temperatures that drop below 9 degrees Celsius (48 degrees Fahrenheit) in the fall (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1993).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993; Baxter *et al.* 1997; Rieman et al. 1997). Optimum incubation temperatures for bull trout eggs range from 2 to 4 degrees Ceslisus (35 to 39 degrees Fahrenheit) whereas optimum water temperatures for rearing range from about 8 to 10 degrees Celsius (46 to 50 degrees Fahrenheit) (McPhail and Murray 1979; Goetz 1989; Buchanan and Gregory 1997). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 to 9 degrees Celsius (46 to 48 degrees Fahrenheit), within a temperature gradient of 8 to 15 degrees Celsius (46 to 60 degrees Fahrenheit). In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003) found that the probability of juvenile bull trout occurrence does not become high (*i.e.*, greater than 0.75) until maximum temperatures decline to 11 to 12 degrees Celsius (52 to 54 degrees Fahrenheit).

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman *et al.* 1997). Factors that can influence bull trout ability to survive in warmer rivers include availability and proximity of cold water patches and food productivity (Myrick *et al.* 2002). In Nevada, adult bull trout have been collected at 17.2 degrees Celsius (63 degrees Fahrenheit) in the West Fork of the Jarbidge River (S. Werdon, U.S. Fish and Wildlife Service, pers. comm. 1998) and have been observed in Dave Creek where maximum daily water temperatures were 17.1 to 17.5 degrees Celsius (62.8 to 63.6 degrees Fahrenheit) (Werdon 2000). In the Little Lost River, Idaho, bull trout have been collected in water having temperatures up to 20 degrees Celsius (68 degrees Fahrenheit); however, bull trout made up less than 50 percent of all salmonids when maximum summer water temperature exceeded 15 degrees Celsius (59 degrees Fahrenheit) and less than 10 percent of all salmonids when temperature exceeded 17 degrees Celsius (63 degrees Fahrenheit) (Gamett 1999). In the Little Lost River study most sites that had high densities of bull trout were in an area where primary productivity increased in the streams following a fire (B. Gamett, U. S. Forest Service, pers. comm. 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris[†], undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich 1996; Sexauer and James 1997; Watson and Hillman 1997). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability[†] and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993). Pratt (1992) indicated that increases in fine sediment† reduce egg survival and emergence.

Bull trout typically spawn from August to November during periods of decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989). Redds† are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992), and after hatching, juveniles remain in the substrate. Time from egg deposition to emergence of fry† may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

Migratory forms of bull trout appear to develop when habitat conditions allow movement between spawning and rearing streams† and larger rivers or lakes where foraging opportunities may be enhanced (Frissell 1993). For example, multiple life history forms (*e.g.*, resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams and lakes, greater fecundity resulting in increased reproductive potential, and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Rieman and McIntyre 1993; MBTSG 1998; Frissell 1999). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbance makes local habitats temporarily unsuitable, the range of the species is diminished, and the potential for enhanced reproductive capabilities are lost (Rieman and McIntyre 1993).

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Brown 1994; Donald and Alger 1993). In coastal areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) in the ocean (WDFW *et al.* 1997).

Bull trout migrations and life history strategies are closely related to their feeding and foraging strategies. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one choice of food over another. For example, prey often occur in concentrated patches of abundance (“patch model”; Gerking 1998). As the predator feeds the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. In the Skagit River system, anadromous bull trout make migrations as long as 195 kilometers (121 miles) between marine foraging areas in Puget Sound and headwater[†] spawning grounds, foraging on salmon eggs and juvenile salmon along their migratory route (WDFW *et al*. 1997). Anadromous bull trout also use marine waters as migratory corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Brenkman, *in litt*., 2003; Brenkman and Corbett, *in litt*., 2003; Goetz, *in litt*., 2003a,b).

A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, but this foraging strategy can change from one life stage to another. Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994) and as fish grow their foraging strategy changes as their food changes in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, mysids[†] and small fish (Shepard *et al*. 1984; Boag 1987; Goetz 1989; Donald and Alger 1993). Bull trout 110 millimeters (4.3 inches) long or longer commonly have fish in their diet (Shepard *et al*. 1984), and bull trout of all sizes have been found to eat fish half their length (Beauchamp and Van Tassell 2001). Migratory bull trout begin growing rapidly once they move to waters with abundant forage that includes fish (Shepard *et al*. 1984; Carl 1985). As these fish mature they become larger bodied predators and are able to travel greater distances (with greater energy expended) in search of prey species of larger size and in greater abundance (with greater energy acquired). In Lake Billy Chinook as bull trout became increasingly piscivorous† with increasing size, the prey species changed from mainly smaller bull trout and rainbow trout for bull trout less than 450 millimeters (17.7 inches) in length to mainly kokanee for bull trout greater in size (Beauchamp and Van Tassell 2001).

Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Bull trout likely move to or with a food source. For example, some bull trout in the Wenatchee basin were found to consume large numbers of earthworms during spring runoff in May at the mouth of the Little Wenatchee River where it enters Lake Wenatchee (USFWS 2003, in prep.). In the Wenatchee River radio-tagged bull trout moved downstream after spawning to the locations of spawning chinook and sockeye salmon and held for a few days to a few weeks, possibly to prey on dislodged eggs, before establishing an overwintering area downstream or in Lake Wenatchee (USFWS 2003, in prep.).

Reasons for Decline

Throughout their range in the lower 48 states bull trout have been negatively impacted by the combined effects of a variety of factors, including habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, fisheries management practices, entrainment†, and the introduction of nonnative species†. Habitat alteration, primarily through the construction of impoundments, dams, and water diversions, has fragmented habitats, eliminated migratory corridors, and isolated bull trout in the headwaters of tributaries (Rieman et al. 1997; Dunham and Rieman 1999; Spruell *et al.* 1999; Rieman and Dunham 2000). The combination of such factors has resulted in rangewide declines in bull trout distribution, abundance, and habitat quality, as well as the reduction or elimination of migratory bull trout. Threats specific to bull trout within the Coastal-Puget Sound Distinct Population Segment are identified in the listing rule (64 FR 58910).

Populations of migratory bull trout require abundant fish forage and it is likely that many bull trout populations have been affected by declines in salmon populations. Bull trout are a piscivorous fish whose existence and historical abundance throughout much of their range was historically connected with, and most likely dependent on, healthy salmon populations (Armstrong and Morrow 1980; Brown 1994; Nelson and Caverhill 1999; Baxter and Torgerson, *in litt*., 2003). In parts of their range, especially in the Coastal-Puget Sound Distinct Population Segment, salmon continue to provide an important food source (Kraemer, *in litt*., 2003). Food resources provided by salmon include dislodged eggs, emergent and migrating fry, and smolts[†]. In addition, bull trout benefit from the increased productivity supplied by the decomposing carcasses of adult salmon.

Recent publications have documented the recent declines and low abundance of Pacific salmon populations throughout much of their range within the coterminous United States (WDF *et al*. 1993; NMFS 1991; NOAA, *in litt*., 2003). In 1991, the American Fisheries Society published a status list of 214 naturally spawning stocks[†] of salmon, steelhead, and cutthroat trout from California, Oregon, Idaho and Washington. Their assessment included 101 stocks at high risk of extinction, 58 stocks at moderate risk of extinction, 54 stocks of special concern, and one classified as threatened under the Endangered Species Act (Nehlsen *et al*. 1991).

Detailed information on specific threats to bull trout in the Puget Sound Management Unit (see "Recovery Plan Terminology and Structure," below) is provided in Part II of this plan.

SIGNIFICANCE OF THE COASTAL-PUGET SOUND DISTINCT POPULATION SEGMENT

The full array of bull trout resident and migratory life history forms are found in the Coastal-Puget Sound Distinct Population Segment. Bull trout occurring here may be residents, or they may exhibit one of several migratory behaviors. Adfluvial bull trout migrate from tributary streams to a lake or reservoir to mature, and return to a tributary to spawn, and fluvial bull trout migrate from tributary streams to larger rivers to mature and then return to tributaries to spawn.
Of particular significance, the Coastal-Puget Sound Distinct Population Segment supports the only known anadromous form~~s~~ of bull trout within the coterminous United States. These fish hatch in freshwater, migrate to and from the ocean to grow and live as adults, and then return to freshwater to spawn.

The restoration and preservation of the migratory life history forms of bull trout will be an important factor in providing for the recovery of the species. Migratory barriers that have resulted in the loss of the migratory forms have been shown to negatively impact bull trout by increasing the probability of losing individual local populations (Rieman and McIntyre 1993), increasing the probability of hybridization[†] with introduced brook trout (Rieman and McIntyre 1993), reducing the potential for movements in response to developmental, foraging, and seasonal habitat requirements (MBTSG 1998), reducing reproductive capability by eliminating the larger, more fecund migratory form (MBTSG 1998; Rieman and McIntyre 1993), and reducing the geographic range of the species. Restoring and maintaining migratory corridors will ensure the persistence of migratory bull trout and allow individuals access to unoccupied but suitable habitats, foraging areas, and refuges from disturbances (Saunders *et al.* 1991). Furthermore, maintenance of migratory corridors for bull trout is essential to provide connectivity[†] among local populations, and enables the reestablishment of extirpated[†] populations. Where migratory bull trout are not present, isolated populations cannot be replenished when a disturbance makes local habitats temporarily unsuitable (Rieman and McIntyre 1993; USDA and USDI 1997).

Of the five distinct population segments of bull trout, only the Coastal-Puget Sound Distinct Population Segment provides the opportunity to conserve all known life history forms of the species. In the final listing rule, we determined that the Coastal-Puget Sound Distinct Population Segment of bull trout occurs in a unique ecological setting because it supports the only known anadromous forms of bull trout in the coterminous United States. In addition, it was determined that the loss of this population segment would significantly reduce the overall range of the taxon (64 FR 58910). Since the original listing, mitochondrial DNA data has revealed genetic differences between coastal populations of bull trout, including the lower Columbia and Fraser rivers, and inland populations in the upper Columbia and Fraser river drainages east of the Cascade and Coast Mountains (Williams *et al.* 1997; Taylor *et al.* 1999). This divergence is likely based on recolonization patterns associated with glacial refugia 10,000 to 15,000 years ago (Haas and McPhail 2001; Costello *et al.* 2003; Spruell *et al.* 2003), and suggests the existence of two or more genetically differentiated lineages of bull trout, each with a unique evolutionary legacy. Although this recent genetic evidence suggests some degree of shared evolutionary potential between all coastal populations of bull trout, these major assemblages are further subdivided at the level of major river basins (Spruell *et al.* 2003) and this, in conjunction with the unique occurrence of anadromy within the Coastal-Puget Sound Distinct Population Segment, suggests that it is appropriate to continue to focus our recovery efforts on this distinct population segment as we evaluate the potential implications of recent genetic analyses on the organization of bull trout recovery efforts.

RECOVERY PLAN TERMINOLOGY AND STRUCTURE

The bull trout is a wide-ranging species with multiple life history forms and a complex population structure reflecting a high degree of local site fidelity (Kanda and Allendorf 2001) and substantial genetic divergence between breeding populations (Dunham and Rieman 1999; Spruell *et al.* 2003). Furthermore, it has been suggested that maintaining variability in life history strategies and dispersal over many habitats may be as important to bull trout conservation as maintaining genetic variability (Rieman and Allendorf 2001). In order to preserve the diverse array of life histories and genetic variability exhibited by bull trout across their range, this recovery plan utilizes the concept of "core areas[†]." A **core area** represents a combination of suitable habitat and one or more **local populations** (the smallest group of fish that are known to represent an interacting reproductive unit) that function as one demographic unit due to occasional gene flow between them; essentially, most core areas function as metapopulations[†] (Meffe and Carroll 1994; Hanski and Gilpin 1997; Dunham and Rieman 1999). A **metapopulation** can be defined as a collection of relatively isolated, spatially distributed local populations bound together by occasional dispersal between them. Local populations may be extirpated, but can be reestablished by individuals from other local populations, although, as stated earlier, genetic analysis indicates this will likely take a very long time. In general, the characteristics of most bull trout populations appear to be consistent with the metapopulation concept, although the exact structure of bull trout metapopulations is not well understood (Rieman and McIntyre 1993).

For the purposes of recovery, we defined core areas – which represent both suitable habitat as well as a demographically dependent grouping of local populations – as the most biologically meaningful population units to work with to ensure the long-term viability of bull trout. The key to bull trout recovery lies in providing an interconnected continuum of complex habitats which support diverse life histories and life cycles to maintain gene flow and genetic variation and facilitate metapopulation dynamics within core areas. To achieve this goal, we developed a hierarchical approach to bull trout recovery, and further subdivided the Coastal-Puget Sound Distinct Population Segment into two individual **management units**, the Puget Sound Management Unit and the Olympic Peninsula Management Unit. Focusing recovery on these smaller areas is advantageous because bull trout are broadly distributed, use a variety of habitats, and the factors affecting them vary widely at the scale of the distinct population segment. A narrower scope allows recovery actions to be tailored to specific areas and encourages the implementation of actions by local interests. The delineation of these management units was based on presumed shared genetic characteristics (*i.e.*, groupings of bull trout within isolated basins, major river basins, or collections of basins with potential for current or historical gene flow) as well as jurisdictional and logistical concerns (*e.g.*, the international boundary with Canada represents the northern boundary of the management units). The intent of the management units is to foster effective management and promote local management decisions regarding bull trout as well as to preserve the evolutionary legacy shared between the multiple bull trout core areas that comprise each of the units.

The recovery of the Coastal-Puget Sound Distinct Population Segment of bull trout will depend upon the achievement of recovery goals and criteria for the entire distinct population segment. Maintenance of fully functioning core areas across the range of bull trout within the population segment will require that each of the two management units that comprise this distinct population segment contribute to the success of this effort. In keeping with the goal of fostering effective management and recovery of bull trout at the local level, we have developed separate recovery plans for each of these management units, and established specific “**recovery targets**” for each management unit that will be used to guide bull trout recovery within the distinct population segment as a whole.

Presently bull trout are listed across their range within the coterminous United States (64 FR 58910). Prior to the coterminous listing in 1999, five distinct population segments of bull trout were identified. Although the bull trout distinct population segments are disjunct and geographically isolated from one another, they include the entire distribution of bull trout in the coterminous United States. In accordance with our Distinct Population Segment policy (61 FR 4722), a coterminous listing was found to be appropriate when all five distinct population segments were determined to warrant listing. As provided in the final listing rule, however, we continue to refer to these populations as distinct population segments for recovery planning purposes (64 FR 58910).

A delisting determination can only be made on a “listable entity” under the Endangered Species Act; listable entities include species, subspecies, or distinct population segments of vertebrate animals, as defined by the Endangered Species Act and U.S. Fish and Wildlife Service policy (61 FR 4722). Because bull trout were listed at the coterminous level in 1999, currently delisting can only occur at the coterminous level (64 FR 58910). In the future, if warranted by additional information, and if the Coastal-Puget Sound population is reconfirmed as meeting the definition of a distinct population segment under a regulatory rulemaking process, delisting may be considered separately for the Coastal-Puget Sound Distinct Population Segment of bull trout once it has achieved a recovered state.

Here we define the recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment of bull trout as currently delineated. The site-specific strategies, recovery actions, and recovery targets for the Puget Sound Management Unit are presented in Part II of this plan. The Olympic Peninsula Management Unit is addressed in its own recovery plan.

RECOVERY GOALS AND OBJECTIVES

Recovery Goal

The goal of this recovery plan is to **ensure the long-term persistence of self-sustaining, complex, interacting groups[†] of bull trout distributed across the Coastal-Puget Sound Distinct Population Segment so that the species can be delisted.** To accomplish this goal, recovery objectives addressing distribution, abundance, habitat and genetics were identified.

Recovery Objectives

The recovery objectives for the Coastal-Puget Sound Distinct Population Segment are as follows:

- Maintain the current distribution of bull trout anadromy and restore migratory life history forms in some of the previously occupied areas.

- Maintain stable or increasing trends in abundance of bull trout.

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies with an emphasis on anadromy.

- Conserve genetic diversity and provide opportunity for genetic exchange to conserve migratory life history forms.

Recovery Criteria

Achieving recovery criteria and making formal delisting decisions are two separate processes. Delisting requires that a five factor analysis[2] in a regulatory rulemaking process demonstrates that the threats to the species have been reduced or eliminated to the point that the species no longer requires the protections of the Endangered Species Act. The recovery criteria established in a recovery plan for a threatened species, such as the bull trout, are intended to serve as clear, measurable guidelines for assessing the conditions under which such a five factor analysis would likely result in a determination that the species warrants delisting (*i.e.*, that it no longer meets the definition of "threatened," which is "any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range"). A delisting decision therefore considers both the attainment of the recovery criteria as defined in a recovery plan and the outcome of a formal five factor analysis in a regulatory rulemaking.

The Coastal-Puget Sound Distinct Population Segment will be considered recovered when all core areas are fully functional, as measured by parameters addressing the distribution, abundance, productivity (stable or increasing adult population trend), and connectivity (including the potential for expression of all life history traits) of bull trout. The conditions for recovery are identified in the criteria below. The recovery actions identified in this plan are designed to sufficiently control or eliminate the threats to bull trout such that the recovery

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The five factors considered in delisting decisions are the same as those considered in the initial listing process for a species: a) the present or threatened destruction, modification, or curtailments of its habitat or range; b) overutilization for commercial, recreational, scientific, or educational purposes; c) disease or predation; d) the inadequacy of existing regulatory mechanisms; and e) other natural or manmade factors affecting its continued existence.

criteria may be attained for the Coastal Puget Distinct Population Segment of bull trout.

Recovery criteria for the Coastal-Puget Sound Distinct Population Segment:

1. **The biological and ecological function of the 14 identified core areas (8 in the Puget Sound Management Unit and 6 in the Olympic Peninsula Management Unit) for bull trout within the distinct population segment has been restored. The components of fully functioning core areas include:**

a) **Habitat sufficiently maintained or restored to provide for the persistence of broadly distributed local populations supporting the migratory life form within each core area.** The term “broadly distributed” implies that local populations are able to access and are actively using habitat that fully provides for spawning, rearing, foraging, migrating, and overwintering needs at recovered abundance levels. An actual quantitative estimate of the amount of habitat that will be required to meet this criterion is unknown at this time; the adequacy of habitat restoration and management efforts must be measured indirectly by criteria 1b through 1d. The currently identified local populations that will be used as a measure of broad distribution across the distinct population segment are detailed in the recovery targets set for each of the two management units.

b) **Adult bull trout are sufficiently abundant to provide for the persistence and viability of core areas; this level of abundance is estimated to be 16,500 adult bull trout across all core areas.** Resident life history forms are not included in this estimate, but are considered a research need. As more data is collected, recovered population estimates will be revised to more accurately reflect both the migratory and resident life history components. The recovery team[†] has initially set abundance targets conservatively if there was limited available information for constituent core areas; these will likely be revised as new information becomes available. The recovered abundance levels for the currently identified core areas in the distinct population segment are detailed in the recovery targets set for each of the two management units.

c) **Measures of bull trout abundance within all core areas show stable or increasing trends based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data.** Details are provided in the recovery targets for each of the two management units.

d) **Habitat within, and where appropriate, between core areas, is connected so as to provide for the potential of the full expression of migratory behavior (particularly anadromy), allow for the refounding† of extirpated populations, and provide for the potential of genetic exchange between populations.** Meeting this criterion requires that passage has been restored or improved, and in some cases further evaluated, at specific barriers identified as inhibiting recovery (including barriers due to physical obstructions, unsuitable habitat, and poor water quality). Known barriers to passage within the Puget Sound Management Unit include the Bellingham Diversion, Gorge Dam, Ross Dam, Tacoma Headworks diversion dam, and Howard Hansen Dam; the Baker River Dams and Electron and Buckley diversions are also in need of passage improvement. Known barriers to passage within the Olympic Peninsula Management Unit include Cushman Dams 1 and 2, Elwha Dam and Glines Canyon Dam, the Washington Department of Fish and Wildlife Dungeness Fish Hatchery, and U.S. Fish and Wildlife Service Quinault National Fish Hatchery. Details regarding these specific barriers are provided in the recovery targets set for each of the two management units.

Meeting this criterion also requires that conditions in both freshwater and nearshore marine foraging, migration, and overwintering habitats† are maintained and/or restored to the level that fully support an adequate prey base, especially for the anadromous forms, as well as the other identified components (distribution, abundance, and trend) for fully functional core areas within the Coastal-Puget Sound population segment.

2. A monitoring plan has been developed and is ready for implementation, to cover a minimum of 5 years post-delisting, to ensure the ongoing recovery of the species and the continuing effectiveness of management actions.

PART II. PUGET SOUND MANAGEMENT UNIT

INTRODUCTION

Management Unit Designation

As described in Part I of this plan, two management units, the Puget Sound and the Olympic Peninsula, have been designated in the Coastal-Puget Sound Distinct Population Segment of bull trout based on presumed biological and genetic factors common to bull trout within specific geographic areas (Figure 1). Although genetic data informing population structure in this area is incomplete, we believe that bull trout populations in watersheds originating from the Olympic Peninsula are likely different from those populations in watersheds originating from the West Cascades flowing into Puget Sound. Although these two management units are connected by marine waters, there is currently no evidence indicating that bull trout from one unit migrate to the other. Recent studies suggest that migrations through marine waters, at least currently, are more localized in nature (Kraemer 1994; F. Goetz, U.S. Army Corps of Engineers, pers. comm. 2002).

The Puget Sound and Olympic Peninsula Management Units for bull trout differ slightly from Washington State's salmon recovery regions described in the 1999 draft statewide strategy to recover salmon, "Extinction Is Not An Option" (WGSRO 1999). The salmon recovery strategy includes Hood Canal watersheds and some Strait of Juan de Fuca watersheds in the Puget Sound region.

The Puget Sound Management Unit encompasses the geographic area of the Puget Sound region bounded by the Cascade crest on the east, the Kitsap Peninsula on the west, and Canadian border to the north. The management unit includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound. This management unit also includes the Chilliwack River watershed, a transboundary system flowing into British Columbia and discharging into the Fraser River.

Based on survey data and professional judgement, the Puget Sound Recovery Team identified eight core areas (Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse Lake, and Puyallup) in the management unit (Figure 2). Core areas consist of core habitat[†] that could supply all the necessary elements for every lifestage of bull trout (*e.g.*, spawning, rearing, migration, overwintering, foraging), and have one or more local populations of bull trout. The demographically linked populations of bull trout and their associated habitat in core areas form the basic units upon which recovery will be gauged within the management unit. In addition, the Puget Sound Recovery Team also identified the Samish River, Lake Washington system, Lower Green River, Lower Nisqually River, and marine areas of Puget Sound as containing important foraging, migration, and overwintering habitat necessary for bull trout recovery (Figure 2). Although there is currently insufficient information available to assign each of these important foraging, migration, overwintering habitats to a specific core area(s), they are believed to be critical to the persistence of the anadromous life history form, unique to the Coastal-Puget Sound population segment. These habitats currently outside of designated core areas support the unique and complex migratory behaviors and requirements of anadromous bull trout. Once sufficient information is gathered on anadromous bull trout movements within the management unit, the current core area boundaries should be revised to depict the relationship between the individual core areas and these important foraging, migration, and overwintering habitats.

The Puget Sound Management Unit includes reservation land, Tribally-owned lands, or Tribal fishing areas of the Lummi Nation, Muckleshoot Tribe, Nisqually Tribe, Nooksack Tribe, Puyallup Tribe, Samish Indian Nation, Sauk-Suiattle Tribe, Snoqualmie Tribe, Squaxin Island Tribe, Stillaguamish Tribe, Suquamish Tribe, Swinomish Tribe, Tulalip Tribes, and Upper Skagit Tribe.

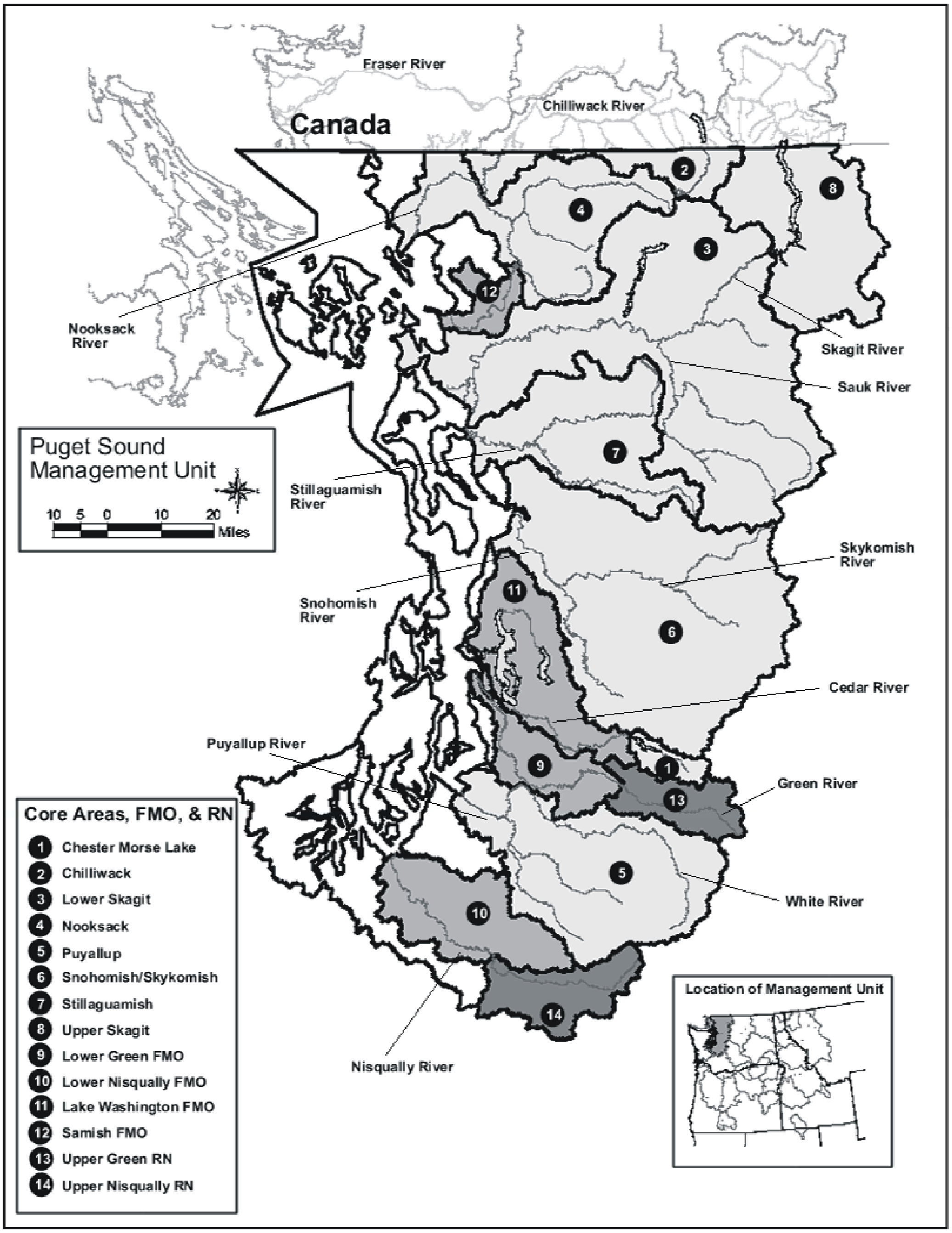

Figure 2. Puget Sound Management Unit showing the eight identified core areas; important foraging, migration, and overwintering habitats (FMO); and research needs areas (RN) for bull trout.

Geographic Description of Management Unit

The Puget Sound Management Unit encompasses the geographic area of the Puget Sound region and includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound (Figure 2). This management unit also includes the Chilliwack River watershed, a transboundary system flowing into British Columbia and discharging into the Fraser River. Historically, these watersheds have been an important area for anadromous salmon (*Oncorhynchus* spp.), steelhead (*O. mykiss*), and bull trout production.

The Puget Sound basin is bounded on the east by the Cascade Range and on the west by the Olympic Mountains, extending north to British Columbia and south to the low hills of the Coast Range near Olympia (Kruckeberg 1991). There are 19 watersheds in the Puget Sound basin. River systems originating from the westside of the Cascades flow westerly and discharge into Puget Sound, the second largest estuary in the United States. The U-shaped valleys of the Puget Sound watersheds were formed primarily during the Vashon glaciation and by the subsequent effects of mountain glaciers. The rivers, creeks, and lowland lakes of the Puget Sound region are the remains of the Vashon glacier and its retreat. Considerable evidence indicates that climate in the Puget Sound region is cyclical, with warm, dry periods and cold, wet periods occurring at decadal intervals (Ebbesmeyer and Strickland 1995).

The Puget Sound basin can be divided, by precipitation and other climatic factors, into two natural provinces: the Puget Sound Province, and Cascade Mountains Province (Campbell 1962). The Puget Sound Province extends from British Columbia south to Oregon and is a lowland region that is mostly less than 305 meters (1,000 feet) in altitude. This province experiences moderate rainfall, ranging from 71 to 140 centimeters (28 to 55 inches) annually. Bedrock consists mostly of Tertiary sedimentary formations and lavas from the numerous volcanos. Vegetation within the province is dominated by Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*). Bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*) are common hardwoods found within the region. Ferns and mosses provide ground cover, while vine maple (*Acer circinatum*) is a significant understory species. The Cascade Mountains Province divides eastern and western Washington. The Cascade Mountain range is approximately 161 kilometers (100 miles) wide in the northern part of the State with peaks generally about 2,400 meters (8,000 feet) above sea level. Mount Rainier, Mount Baker, and Glacier Peak, all above 3,048 meters (10,000 feet), are the principal volcanic peaks found within the Puget Sound Management Unit and Cascade Mountains Province. River systems originating from the Cascades are typically fed by snowmelt or glacier runoff, and by precipitation. The west slope of the Cascades has a temperate marine type of climate that is characterized by mild wet winters and cool summers. The mountains receive high annual snowfall; precipitation may exceed 350 centimeters (140 inches) on the west slope of the Cascades Mountain Range. In the North Cascades, Paleozoic and Mesozoic sedimentary rocks and granite are found, while younger sedimentary and volcanic rocks predominate in the southern portion of the Cascades. Vegetation within the Cascades varies widely with precipitation and elevation. Pacific silver fir (*Abies amabilis*) and noble fir (*A. procera*) dominate at higher elevations, while Douglas fir and western hemlock are less common. Douglas fir, western hemlock, and western red cedar dominate the middle and lower elevations of the western slopes of the Cascades, where precipitation is high. Hardwoods, such as the bigleaf maple (*Acer macrophyllum*), vine maple, red alder, madrone (*Arbutus menziesii*), black cottonwood (*Populus trichocarpa*), and Oregon ash (*Fraxinus latifolia*), grow near streams and in other wet areas.

Major rivers within the Puget Sound Management Unit include the Skagit, with a drainage area of approximately 8,011 square kilometers (3,093 square miles), and the Snohomish River, with a drainage area of approximately 3,973 square kilometers (1,534 square miles). The other river systems within the management unit range in drainage area from the Samish River, with 228 square kilometers (88 square miles), to the Puyallup River, with 2,455 square kilometers (948 square miles). Two annual runoff peaks are common in the river systems within the mountainous terrain of the Pacific Northwest: one in the spring/summer due to snowmelt, and one in the autumn/winter due to prolonged or intense rainfall or rain on snow events (Millard *et al.* 2002).

Puget Sound is a fjord-like estuary and covers an area of about 2,330 square kilometers (900 square miles), including 3,700 kilometers (2,300 miles) of coastline. This body of water is subdivided into five regions: 1) North Puget Sound; 2) Main Basin; 3) Whidbey Basin; 4) South Puget Sound; and 5) Hood Canal. The average depth of Puget Sound is 62.5 meters (205 feet) at mean low tide, the average surface water temperature is 12.8 degrees Celsius (55 degrees Fahrenheit) in summer and 7.2 degrees Celsius (45 degrees Fahrenheit) in winter (Staubitz *et al.* 1997). It was designated as an "Estuary of National Significance" by the U.S. Environmental Protection Agency in 1988 (Kruckeberg 1991). Steep cliffs, largely made of glacial deposits, dominate most of the shoreline, with narrow beaches occurring at the toe of the bluffs and headlands. Extensive tidal flats are located at the river deltas.

Nearly 4 million people, 70 percent of Washington State's population, reside in the Puget Sound Basin (Ebbert *et al.* 2000). By 2020, the population is expected to increase by 1.1 million people, with growth focused in urban and suburban areas. Land use and cover is predominantly forest in the foothills and mountains, while urban and agricultural land uses are concentrated in the lowlands. Generally, heavy industry is located on the shores of urban bays and along the lower reaches of their tributaries, such as Elliott Bay and the Duwamish Waterway and Commencement Bay and the Puyallup River. More than half of the agricultural acreage in the basin is located in Whatcom, Skagit, and Snohomish Counties.

Within the State of Washington, the number of fish species is generally low in headwater streams at high elevations and increases downstream in larger streams and rivers with more diverse habitats (Beecher *et al.* 1988). Within the Puget Sound Management Unit, more than 35 species of native freshwater fishes exist (Table 1). Several nonnative fish species occur within the management unit that are known or suspected to have impacts to bull trout, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and westslope cutthroat trout (*O. clarki lewisi*). Marine and estuarine species within the management unit known to be important prey for bull trout include sandlance (*Ammodytes hexapterus*), surf smelt (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasi*), and shiner perch (*Cymatogaster aggregata*). Chinook salmon (*O. tshawytscha*)

Table 1. Native fish species inhabiting freshwater within the Puget Sound Management Unit (Wydoski and Whitney 2003).

Common name	Scientific name	Occurrence
Pacific lamprey	*Lampetra tridentata*	Anadromous
River lamprey	*L. ayresi*	Anadromous
Western brook lamprey	*L. richardsoni*	Freshwater
White sturgeon	*Acipenser transmontanus*	Anadromous; Freshwater
Coastal cutthroat trout	*O. clarki clarki*	Anadromous; Freshwater
Pink salmon	*O. gorbuscha*	Anadromous
Chum salmon	*O. keta*	Anadromous
Coho salmon	*O. kisutch*	Anadromous
Steelhead/rainbow trout	*O. mykiss*	Anadromous; Freshwater
Kokanee/sockeye salmon	*O. nerka*	Freshwater; Anadromous
Chinook salmon	*O. tshawytscha*	Anadromous
Pygmy whitefish	*Prosopium coulteri*	Freshwater
Mountain whitefish	*P. williamsoni*	Freshwater
Bull trout	*Salvelinus confluentus*	Freshwater; Anadromous
Dolly Varden	*S. malma*	Freshwater; Anadromous?
Longfin smelt	*Spirinchus thaleichthys*	Anadromous; Freshwater
Eulachon	*Thaleichthys pacificus*	Anadromous
Olympic mudminnow	*Novumbra hubbsi*	Freshwater
Lake chub	*Couesius plumbeus*	Freshwater

Table 1 (continued). Native fish species inhabiting freshwater within the Puget Sound Management Unit (Wydoski and Whitney 2003).

Common name	Scientific name	Occurrence
Peamouth	*Mylocheilus caurinus*	Freshwater
Northern pikeminnow	*Ptychocheilus oregonensis*	Freshwater
Longnose dace	*Rhinichthys cataractae*	Freshwater
Umatilla dace	*R. umatilla*	Freshwater
Speckled dace	*R. osculus*	Freshwater
Redside shiner	*Richardsonius balteatus*	Freshwater
Longnose sucker	*Catostomus catostomus*	Freshwater
Largescale sucker	*C. macrocheilus*	Freshwater
Three-spine stickleback	*Gasterosteus aculeatus*	Marine; Freshwater
Shiner perch	*Cymatogaster aggregata*	Marine; Freshwater
Coastrange sculpin	*Cottus aleuticus*	Freshwater
Prickly sculpin	*C. asper*	Freshwater
Shorthead sculpin	*C. confusus*	Freshwater
Riffle sculpin	*C. gulosus*	Freshwater
Reticulate sculpin	*C. perplexus*	Freshwater
Torrent sculpin	*C. rhotheus*	Freshwater
Pacific staghorn sculpin	*Leptocottus armatus*	Marine; Freshwater
Starry flounder	*Platichthys stellatus*	Marine; Freshwater

are currently listed as a threatened species under the Endangered Species Act within the management unit (March 24, 1999; 64 FR 14308), and coho salmon (*O. kisutch*) in the management unit are identified as a species of concern. More than 30 anadromous salmonid production facilities that produce and release Chinook, coho, chum (*O. keta*), and sockeye salmon (*O. nerka*) and steelhead exist in the management unit. Dolly Varden (*Salvelinus malma*) have been proposed for listing as a threatened species within Washington State, based on their similarity of appearance to bull trout (January 9, 2001; 66 FR 1628).

Description of Core Areas

Chilliwack core area. The Chilliwack River basin is a transboundary system flowing from the United States into British Columbia, Canada. Its major tributary, the Sumas River, occupies a long flat valley bordered on the southeast by Vedder Mountain and on the northwest by Sumas Mountain. It begins in Whatcom County and flows across the border to Canada and into the Vedder River, which flows to the Fraser River at the mouth of the Vedder Canal (Healey 1997). Upstream from the confluence with the Chilliwack River, approximately half (83.8 square kilometers; 52.1 square miles) of the Sumas watershed's total area is located in the United States. This U.S. portion is zoned approximately 48.6 percent agriculture, 28.0 percent forestry, 20.2 percent rural, and 3.4 percent urban (Blake and Peterson 2002). The Canadian portion of the watershed exists mostly within the District of Abbotsford, British Columbia, and is physically characterized as a low-lying floodplain[†] referred to as the Sumas Prairie, bordered by steep mountains on both sides.

The Chilliwack River occupies a broad, west-trending valley. It is also a tributary to the Fraser River in British Columbia, while its upper reaches originate in Washington State. Subbasins of the Chilliwack River in general have steep valley sidewalls with narrow valley floors (Millard *et al.* 2002). Stream channels within subbasins tend to be deeply incised. Tributaries to the Chilliwack River include Damfino Creek, Frost Creek and Silesia Creek. Tomyhoi Creek is a tributary to Damfino Creek.

The Chilliwack River flows through mountainous, forested terrain in Washington State, crosses the Canadian border and flows into Chilliwack Lake. Chilliwack Lake, located in Chilliwack Lake Provincial Park, approximately 48 kilometers (30 miles) southeast of the town of Chilliwack, is 12 square kilometers (4.6 square miles) in size, with a mean depth of 67 meters (220 feet) and a maximum depth of 114 meters (374 feet). It is 625 meters (2,050 feet) above sea level and drains into the Vedder River. From there the river flows into the Sumas

River which drains into the Fraser River (Cleary 2001). The Chilliwack watershed is approximately 314 square kilometers (121 square miles) in size with an elevation range of 550 to 1,740 meters (1,804 to 5,709 feet). The Chilliwack River is the most productive system in the Fraser-Delta area (Swain *et al.* 1985). The Chilliwack valley experiences heavy precipitation during the winter and relatively warm, moist summers; average annual precipitation is 113 centimeters (44 inches).

Nearly the entire portion of the Chilliwack River (99 percent) within Washington State is in the North Cascades National Park and has been managed as designated Wilderness. Under the U.S. Northwest Forest Plan the Chilliwack River is a Tier 1 Key Watershed in the Aquatic Conservation Strategy (USDA 1994a, b). The upper reaches of Silesia Creek, the largest tributary to Chilliwack River, also lie in the Park, while downstream reaches are contained within the Mount Baker-Snoqualmie National Forest. The Washington State reaches of Tomyhoi and Damfino Creeks flow through National Forest lands, while the lands within the United States section of Frost Creek watershed are privately owned timber lands. In Canada, this watershed has been managed for multiple consumptive resource use such as logging, road building, recreation, fish hatcheries, and other activities.

The Chilliwack River has significant anadromous salmon populations (sockeye, coho, and Chinook salmon, native char, and steelhead), as well as resident fish populations, including native char that may be Dolly Varden or bull trout, rainbow trout (*O. mykiss*), cutthroat trout, kokanee (*O. nerka*), and mountain whitefish (*Prosopium williamsoni*). There are two naturally occurring adfluvial bull trout populations within the management unit, one of which is associated with Chilliwack Lake in the upper Chilliwack River drainage.

Nooksack core area. The Nooksack River is located within Whatcom (88 percent) and Skagit (6 percent) Counties within the United States, and within British Columbia, Canada (6 percent), and is the fourth largest tributary to Puget Sound. The Nooksack River Basin drains approximately 2,036 square kilometers (786 square miles) of land, of which 127 square kilometers (49 square miles) is in British Columbia, and consists of two hydrologic provinces: the uplands where streams have steep gradients and cut through bedrock, and the lowlands where streams have low gradients and cut through glacial and interglacial sediments and alluvium (USGS 1969).

In the uplands east of the City of Deming, the Nooksack River has three major forks: the North Fork, Middle Fork, and South Fork. The North and Middle Forks originate from the glaciers and snowfields of Mount Baker and are typically turbid with moderate summer flows due to glacial melt. The Middle Fork enters the North Fork at river mile 40.5 (Williams *et al.* 1975). The South Fork drains snowpack from the Twin Sisters Mountain, with low flows during the summer, and meets the North Fork to form the mainstem at river mile 36.6 (Williams *et al.* 1975) and has a mean annual discharge[†] of 746 cubic feet per second (near Wickersham, Washington; water years 1934 to 1977) (USGS 2001). The North Fork generally experiences peak flows[†] in June and low flows in March, while the South Fork most frequently peaks in May and December, with low flows in August, resulting in divergent flow and water temperature patterns. Mean annual discharge of the North Fork downstream from Cascade Creek is 781 cubic feet per second (water years 1938 to 2001) (USGS 2001). The mean annual discharge for the Middle Fork is 495 cubic feet per second (15 water years from 1921 to 2001) (USGS 2001). Water temperatures in the North Fork are colder than the South Fork.

Streamflows in each of the forks combine just east of Deming, forming the mainstem of the Nooksack River. Here, the mean annual discharge is 3,331 cubic feet per second (59 water years from 1936 to 2001) (USGS 2001). From here, the Nooksack River flows to Bellingham Bay in Puget Sound. In the lowlands, tributaries such as Anderson, Smith, Fishtrap, and Tenmile Creeks, and many others discharge into the Nooksack River.

Natural vegetation within the basin includes western hemlock, western red cedar, red alder, Sitka spruce (*Picea sitchensis*), black cottonwood, Douglas fir, and grand fir (*Abies grandis*). Zoned land use for the Nooksack watershed is about 40 percent Federal, 33 percent forestry, 12 percent agriculture, 11 percent rural, 3 percent urban, 0.7 percent commercial and industrial, and 0.2 percent water and open space (Blake and Peterson 2002).

Water is diverted via a pipeline from the Middle Fork of the Nooksack River to Lake Whatcom, which is used as the municipal water supply for the City of Bellingham (USGS 2001). Lake Whatcom is in the Whatcom Creek watershed, which is separate from the Nooksack River watershed and drains directly into Bellingham Bay. Uses of surface waters from the Nooksack River system include agriculture, industry, municipal water supply, and recreation (USGS 2003).

The surface-water system of the Nooksack Basin lowlands has been extensively altered. In its natural condition, large areas of the lowlands were wetlands. Drainage systems have been installed to lower the water table and dry the land ever since farming by settlers started in the area, in about 1850. Parts of the drainage systems consist of open ditches that are easily identified, while other parts consist of underground structures not visible from the surface. Other alterations to the surface-water system include the diking, leveeing, and redirecting of the Nooksack River, to minimize damage from periodic flooding (USGS 2003). Historically the greater Nooksack delta included distributaries† (natural branches from the main channel) to both Lummi Bay and Bellingham Bay, with extensive estuarine, and riverine-tidal freshwater wetlands, especially on the side of Lummi Bay (Collins and Sheikh 2002). The Lummi Bay distributary was formerly the major channel, and it was closed off from the river in the mid-1880's. Dikes closed delta distributaries and blind tidal channels, meanders were cut off in the lower river, and tributary creeks were ditched (Collins and Sheikh 2002). Much of the Lummi Bay wetlands were diked and drained for agriculture, and Bellingham Bay has had substantial filling of wetlands (WSCC 2002a). The mainstem and lower South Fork Nooksack River historically had very large, full spanning logjams, and the upper mainstem and much of the forks have been transformed from anastomosing channel patterns (a channel which has major distributaries that branch and then rejoin it) to much wider, braided channels† (Collins and Sheikh 2002). The Nooksack River Basin supports all five species of Pacific salmon and is the northern extent of the range for the Nooksack dace (*Rhinichthys* sp.).

Skagit River Basin (encompassing the Lower Skagit and Upper Skagit core areas). The Skagit River is the largest watershed in Puget Sound. It is located within the Cascades (upper watershed) and Puget Lowlands (lower watershed) ecoregions and drains a total of 8,011 square kilometers (3,093 square miles) of land, including 1,036 square kilometers (400 square miles) in British Columbia (USGS 1969). The Skagit Basin is composed of two geographic regions: the lower Skagit River and the upper Skagit River (USGS 2001). The river has an extensive delta in Skagit County.

The Skagit River Basin is located within Skagit (51 percent), Whatcom (30.9 percent), and Snohomish (18.1 percent) Counties. The majority of the watershed is under Federal (67.0 percent) ownership, followed by private (27.3 percent), State (5.3 percent), and Tribal (0.3 percent). Ownership in the lower Skagit Basin is predominately private (83.9 percent), while the majority (86.8 percent) of the upper watershed is Federal. Forestry is the major land use (65.9 percent) in the Skagit Basin, followed by range (9.9 percent), water (6.9 percent), agriculture (4.0 percent), and urban (0.9 percent), with other land uses making up the remaining 12.4 percent. The lower Skagit River watershed has more agriculture (17 percent versus 0 percent), and less forest (49 percent versus 71 percent) and range (3 percent versus 12 percent) use than the upper watershed.

Lower Skagit core area. The Lower Skagit core area includes all of the Skagit basin downstream of the Diablo Dam located at river mile 101 and encompasses approximately 5,260 square kilometers (2,030 square miles). This area includes all of the mainstem Skagit River downstream of Diablo Dam (including Gorge Lake), Cascade, Sauk, Suiattle, White Chuck, and Baker Rivers (including the lake systems upstream from Lower and Upper Baker Dams) and the estuary and nearshore marine areas (*e.g.*, Skagit Bay, Port Susan). Two large reservoirs, Lake Shannon (river mile 1.2) and Baker Lake (river mile 9.3), were created by hydroelectric dams, Lower and Upper Baker Dams, on the Baker River. Gorge Lake, created by Gorge Dam (river mile 96.6), is located on the mainstem Skagit River.

The geology of the lower Skagit River includes rolling moraines and foothills, and floodplains with the surface material of silt loam and gravel/sand loam (WDOE 2000). The geology of the upper Skagit River is glaciated ridges and plateaus, and U-shaped valleys with the surface material of deep sandy-gravelly loams and bare rock and rubble. Natural vegetation includes western hemlock, western red cedar, red alder, and Douglas fir in the lower watershed and Pacific silver fir, subalpine fir (*Abies lasiocarpa*), Douglas fir and other mixed conifers in the upper watershed. Mean annual precipitation in the lower Skagit Basin is 94 centimeters (37 inches) with mean temperatures of 2.2/7.8 degrees Celsius (36.0/46.0 degrees Fahrenheit) in the winter and 11.1/16.7 degrees Celsius (52.0/62.0 degrees Fahrenheit) in the summer (WDOE 2000). Agriculture, urbanization, channel modifications have significantly changed the lower Skagit Valley. Much of the river below Sedro-Woolley has been extensively channelized[†], leveed and armored with riprap[†]. Low flows in the system typically occur in September. Stream flows are also greatly affected by the operations of five reservoirs, three on the upper Skagit River and two on the Baker River. The Skagit River system supports all five species of Pacific salmon and the rare Salish sucker (*Catostomus* sp.).

The Skagit River delta was one of the first in Puget Sound to be converted from tidal wetlands to agriculture (Beechie *et al*. 1994), resulting in the loss of approximately 96 square kilometers of estuarine habitat (37 square miles), or 93 percent of its historical coverage (Dean *et al.* 2000). The Skagit River passes around Fir Island discharging into Skagit Bay. Padilla Bay is a National Estuarine Research Reserve located to the north of Skagit Bay, connected to the southern delta by the Swinomish Channel. There are nearly 32 square kilometers (12.5 square miles) of eelgrass (*Zostera* spp.) in Padilla Bay. Although Padilla Bay is not currently connected to the Skagit River system, historically it was connected periodically through flood flows. One of the alternatives being studied for flood control in the lower Skagit River would permanently connect the river to Padilla Bay.

Upper Skagit core area. The Upper Skagit core area includes the Skagit Basin upstream of Diablo Dam, including Diablo Lake, Ross Lake (created by Ross Dam at river mile 105.2), and the upper Skagit River drainage in British Columbia. The Upper Skagit River core area has a total drainage area of about 2,900 square kilometers (1,125 square miles), including the upper 1,036 square kilometers (400 square miles) of the drainage in British Columbia, Canada. A large portion of this watershed is located within North Cascades National Park, Pasayten Wilderness, Skagit Valley Provincial Park, and Manning Provincial Park.

Mean annual precipitation in the upper Skagit Basin is approximately 254 centimeters (100 inches) with mean temperatures of -10.6/2.2 degrees Celsius (13.0/36.0 degrees Fahrenheit)[3] in the winter and 7.2/21.1 degrees Celsius (44.0/70.0 degrees Fahrenheit) in the summer. Mean annual flow of the lower Skagit River, near Mount Vernon, Washington (river mile 15.9), is 16,710 cubic feet per second with highest flows occurring in June associated with spring/summer snowmelt (USGS 2001). In the upper Skagit, mean annual flow, near Concrete, Washington (river mile 54.9), is 15,040 cubic feet per second with highest flows occurring in the late spring/early summer associated with snowmelt. A second peak flow typically occurs in December associated with fall/winter rain events.

Stillaguamish core area. The Stillaguamish River is the fifth largest tributary to Puget Sound, with a drainage basin of 1,774 square kilometers (685 square miles) (WSCC 1999a). The watershed is mostly within the boundaries of Snohomish County. Above Arlington (river mile 17.4; 804 meters elevation; 2,638 feet), the Stillaguamish River has two major forks: the North Fork and the South Fork. The North Fork drains 42 percent or 736 square kilometers (284 square miles) of the watershed. The South Fork drains 37 percent or 660 square kilometers (255 square miles) of the watershed. The mean annual discharge for the North Fork near Arlington is 1,892 cubic feet per second (73 water years from 1929 to 2001) (USGS 2001). Below the confluence of the forks, the valley gradually slopes westward towards Puget Sound. Pilchuck, Deer, and Canyon Creeks are the three largest tributaries within the basin. Near the mouth of the Stilliguamish River, the mainstem divides into two distributary channels before entering Puget Sound: Hat Slough and Stillaguamish Channel.

The geology of the Stillaguamish watershed is a combination of continental and alpine glacial deposits, and marine and non-marine interglacial

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Mean temperatures are presented in pairs representing the mean low temperature/mean high temperature.

deposits (WSCC 1999a). Mean annual rainfall ranges from 76 cm (30 inches) in the western lowlands to more than 356 cm (140 inches) in the eastern region, with approximately 75 percent of it occurring between October and March. The highest streamflows occur during autumn and winter, while the lowest streamflows occur from July to September. Excess sedimentation, mostly from landslides associated with human land uses, exist within the basin. Conifers comprise most of the vegetation within the basin, consisting of western hemlock, Douglas fir, western red cedar, Sitka spruce, and mountain hemlock (*Tsuga mertensiana*). Within the floodplain, deciduous trees, such as alder, bigleaf maple, willow (*Salix* spp.), cottonwood, and vine maple, predominate.

There are no large hydroelectric or flood control dams within the watershed (WSCC 1999a). However, two diversion structures exist within the watershed, the Cook Slough Weir and the Granite Falls fishway. Side channels and sloughs within the watershed have been disconnected from the main river channel, resulting in a decrease of these habitats by 31 percent from historical levels. Currently, the total freshwater wetland area within this watershed is estimated to be 2,537 hectares (6,268 acres), or 22 percent of the historical level.

Land use within the basin consists of 76 percent forest, 17 percent rural residential, 5 percent agriculture, and 2 percent urban (WSCC 1999a). The predominant land uses in the upper watershed are timber production and dispersed recreation. Agricultural use is concentrated in the valley bottoms along the mainstem, forks, and the larger tributaries. Much of the Stillaguamish Estuary has been converted to agriculture. In addition, nonnative cordgrasses (*Spartina* spp.) have invaded the estuary. Many lakes in the Stillaguamish watershed have been stocked with nonnative and native fish species.

Snohomish-Skykomish core area. The Snohomish-Skykomish core area includes the Snohomish River, its two major tributaries, the Skykomish and Snoqualmie Rivers, and all their tributaries. The Snohomish River Basin, located northeast of Seattle, Washington, is the second largest Puget Sound basin, draining approximately 3,973 square kilometers (1,534 square miles) of land (USGS 1969). The Skykomish and Snoqualmie Rivers originate in steep, narrow valleys in the Cascade Mountains, flow downstream through broad alluvial[†] floodplains, and merge with the mainstem of the Snohomish River near the city of Monroe (Haas and Collins 2001). From there, the river flows for 34.5 kilometers (21.4 miles) through a valley formed by glaciers and empties into Possession Sound between the city of Everett and the Tulalip Indian Reservation.

The Skykomish River Basin drains a total of 1,386 square kilometers (535 square miles) of land (USGS 1969). The mean annual discharge for the Skykomish River near Gold Bar is 3,946 cubic feet per second (73 water years from 1929 to 2001) (USGS 2001). The mean annual discharge for the Snoqualmie River near Carnation is 3,730 cubic feet per second (72 water years from 1930 to 2001) (USGS 2001). The mean annual discharge for the Snohomish River at the confluence of the Snoqualmie and Skykomish Rivers is 9,625 cubic feet per second (Haas and Collins 2001).

Average annual rainfall ranges from 89 to 457 cm (35 to 180 inches) per year (WSCC 2002b). Western hemlock, Douglas Fir, western red cedar, and Sitka spruce are the dominant conifer species present. Deciduous trees present include red alder, black cottonwood, and bigleaf maple.

Chester Morse Lake core area. The Chester Morse Lake core area is located in southeast King County in the upper Cedar River watershed above a natural migration barrier, Lower Cedar Falls. This core area consists of the mountainous upper portion of the Cedar River drainage system within the Cedar River Municipal Watershed. It extends upstream from Lower Cedar Falls (river mile 34.4), through a 2.3-kilometer (1.4-mile) ‘canyon reach' to the Masonry Dam (river mile 35.7) at the west end of the Chester Morse Lake/Masonry Pool reservoir complex and approximately 26 kilometers (16 miles) eastward to the crest of the central Cascades. The hydrographic drainage of the core area is 213 square kilometers (82 square miles) and encompasses five major tributary basins: Chester Morse Lake (47 square kilometers; 28 square miles), upper Cedar River (62 square kilometers; 24 square miles), Rex River (59 square kilometers; 23 square miles), North Fork Cedar River (25 square kilometers; 10 square miles), and South Fork Cedar River (18 square kilometers; 7 square miles), as well as the ‘canyon reach' in the Lower Cedar River major tributary basin (1.8 square kilometers; 0.7 square miles).

The entire hydrographic drainage of the core area is within the 366.4 square kilometer (141.5 square mile) municipal watershed, owned and managed by the City of Seattle. This watershed serves as the major source of water for the City of Seattle and surrounding communities, and has had restricted public access since 1908 to maintain high water quality. The Cedar River watershed above Cedar Falls has a drainage area of 218 square kilometers (84 square miles). The largest water body in the upper Cedar River watershed is Chester Morse Lake, originally called Cedar Lake, which was naturally formed by glaciers. It is approximately 6.4 kilometers (4 miles) long and one kilometer (0.6 miles) wide with an area of about 6.2 square kilometers (2.4 square miles). The water elevation of the lake was raised 9.8 meters (32 feet) following the construction of Crib and Masonry Dams to provide storage for the City of Seattle's water supply. The western end of Chester Morse Lake, Masonry Pool (2.3-kilometer long, 0.8 square kilometers; 1.4-mile miles long, 0.3 square miles), is connected to the main body of the lake by a narrow channel flowing through a terminal glacial moraine. Chester Morse Lake currently has a maximum depth of 41.1 meters (135 feet) at full pool, while Masonry Pool has a depth of approximately 20.4 meters (67 feet) at maximum operating capacity. Masonry Pool is physically separated from Chester Morse Lake during periods of drawdown by a small concrete dam (Crib Dam). The two major tributaries flowing into Chester Morse Lake are the upper Cedar River and Rex River. The upper Cedar River is the larger of these tributaries, having a drainage area of 106 square kilometers (41 square miles). The Rex River has a drainage area of 36 square kilometers (14 square miles).

Only four fish species inhabit the Chester Morse Lake/Masonry Pool reservoir: bull trout, shorthead sculpin (*Cottus confusus*), rainbow trout, and pygmy whitefish (*Prosopium coulteri*) (Wyman 1975; Wydosky and Whitney 2003). The Cedar River Municipal Watershed is dominated by coniferous forest (94.4 percent) typical of the west slope and foothills of the central Washington Cascade Mountain Range (WSCC 2001). Much of this watershed has supported commercial timber harvest for the last 120 years, yielding a mosaic of multi-seral stage[†] forest today. The steep landscape is dominated by second-growth conifer forest with primarily 60 to 69 year old forest up to an approximate elevation of 762 meters (2,500 feet). Patchy, regenerating forest ranging from 20 to 70 years old is found at mid-slope and in some cases to ridge tops. Young forest (*e.g.*, 0 to 9 and 10 to 19 years old) and old forest (190+ years) exist as fragmented and isolated patches along the ridgelines at elevations of about 1,219 meters (4,000 feet) (WSCC 2001). Small patches of mixed coniferous/deciduous forest and/or deciduous forest (mostly red alder) persist adjacent to small tributary drainages and in areas with poor soil drainage.

Puyallup core area. The Puyallup River Basin is the third largest tributary to Puget Sound. It encompasses approximately 272,767 acres (674,000 acres) and is located in the Cascades (upper watershed) and Puget Lowlands (lower watershed) ecoregions (WDOE 2000). The Puyallup core area includes the following major rivers and their tributaries: the Puyallup, Mowich, Carbon, and the White Rivers including the Clearwater, Greenwater, and West Fork White Rivers, and Huckleberry Creek. The Mowich River drains the North and South Mowich and Flett Glaciers and enters the upper Puyallup at river mile 42.3. The Carbon River drains the Carbon and Russel Glaciers and flows westerly to join the mainstem Puyallup River near river mile 18. The White River, the largest tributary to the lower Puyallup River, drains Emmons, Inter, Winthrop and Frying Pan Glaciers on the northeast flank of Mount Rainier located in Mount Rainier National Park. The White River then flows through the Mount Baker-Snoqualmie National Forest and converges with the lower Puyallup River at river mile 10.4. The Puyallup River drains the Tahoma and the Puyallup glaciers on Mount Rainier and flows generally northwest to Commencement Bay. Commencement Bay is approximately 2,307 hectares (5,700 acres) in size and has been substantially altered from its historical condition (WSCC 1999b).

Mean annual precipitation is approximately 165 centimeters (65 inches) with mean temperatures of 0.5/7 degrees Celsius (33/44 degrees Fahrenheit) in the winter and 10/25 degrees Celsius (50/78 degrees Fahrenheit) in the summer. Mean annual flow of the Puyallup River, near Puyallup, Washington (river mile 6.6), is 3,328 cubic feet per second with highest flows occurring from late spring/early summer period associated with spring/summer snowmelt (USGS 2001). Low flows occur in September. Stream flows on the Puyallup River are affected by the diversion at river mile 41.7, which serves Puget Sound Energy's Electron facility, and on the White River by the operations of Mud Mountain

Dam (river mile 29.6) for flood control and the Puget Sound Energy's Buckley diversion dam at river mile 24.2.

The geology of the Puyallup River includes the lowlands (floodplains and terraces) and U-shaped glaciated mountains. Surface materials include silt- and clay-loam, gravelly clay loam, and cobbly loam. Natural vegetation includes western hemlock, western red cedar, red alder, and Douglas fir.

The Puyallup River Basin is located within Pierce (87 percent) and King (13 percent) Counties. Land ownership consists primarily of private lands (57.4 percent), followed by Federal (38.8 percent), Tribal (3.2 percent), and State (0.6 percent). Land use in the Puyallup River Basin includes: forestry (66 percent), urban (8 percent), range (4 percent), agriculture (4 percent), water (3 percent), and other (15 percent). Many of the headwater reaches of the Puyallup Basin are within either Mount Rainier National Park or designated Wilderness areas (WSCC 1999b). Extensive urban growth, heavy industry, a large marine port, revetments[†] and levees, and agriculture have altered the lower landscape. Commencement Bay is surrounded on three sides by industry, commercial and residential influences (WSCC 1999b). Dredging, filling, and diking of the habitat have largely eliminated historical, off-channel distributary channels and sloughs. For example, an estimated 72 of the original 850 hectares (180 of the original 2,100 acres) of historical intertidal mudflat remains today.

Samish River foraging, migration, and overwintering habitat. The Samish River Basin is located north of the Skagit River Basin and drains a total of 228 square kilometers (88 square miles) of land (USGS 1969). Lake Samish is located on Friday Creek, a tributary to Samish River, 10.5 kilometers (6.5 miles) southeast of Bellingham. Mean annual discharge for the Samish River, near Burlington, is 246 cubic feet per second (1944 to 2001) (USGS 2001). During very high flows (over 146,000 cubic feet per second) at Mount Vernon, a portion of the Skagit River can overflow to the Samish River and Bay. Land use in the floodplain is primarily rural with some suburban development.

Lake Washington foraging, migration, and overwintering habitat. The Lake Washington foraging, migration, and overwintering habitat consists of the lower

Cedar River, the Sammamish River, Lakes Washington, Sammamish and Union, the Lake Washington Ship Canal, and all accessible tributaries and lakes. The upper Cedar River Watershed above Cedar Falls is a separate core area and not included in this description.

Lake Washington is a large monomictic (one regular period of mixing) lake with a total surface area of 95 square kilometers (37 square miles), a mean depth of 33 meters (108 feet), and approximately 129 kilometers (80 miles) of shoreline (WSCC 2001). The lake typically stratifies from June through October. Surface water temperatures range from 4 to 6 degrees Celsius (39 to 43 degrees Fahrenheit) in winter to over 20 degrees Celsius (68 degrees Fahrenheit) in summer. Residential land use comprise over 78 percent of the shoreline. During winter (December to February) the lake level is kept low at an elevation of 6.1 meters (20 feet). Starting in late February the lake level is slowly raised to 6.6 meters by May 1 and 6.7 meters (21.6 and 22.0 feet) by June 1. The Ballard Locks, located at the downstream end of the Ship Canal, controls the lake level.

The major tributary to Lake Washington is the Cedar River which enters the lake at the south end. The river originates at approximately 1,220 meter (4,002 feet) elevation and over its 80 kilometer (50 mile) course falls 1,180 meters (3,871 feet) in elevation. Prior to 2003, Landsburg Dam, a water diversion structure, prevented fish from migrating upstream of river mile 21.8.

Beginning in 1912, drainage patterns of the Cedar River and Lake Washington were extensively altered (Weitkamp and Ruggerone 2000). Most importantly, the Cedar River was diverted into Lake Washington from the Duwamish River watershed, and the outlet of the lake was rerouted through the Ship Canal. Lake Sammamish is within the Lake Washington basin and is located just east of Lake Washington. Lake Sammamish has a surface area of 19.8 square kilometers (7.6 square miles) and a mean depth of 17.7 meters (58 feet). Most of the shoreline is in residential land use. Issaquah Creek is the major tributary to the lake and enters the lake at the south end.

The Ship Canal is a 13.8 kilometer (8.6 mile) artificial waterway that is located between Lake Washington and Puget Sound. The Ship Canal consists of five sections, Montlake Cut, Portage Bay, Lake Union, Fremont Cut, and the Salmon Bay waterway. The largest part of the Ship Canal is Lake Union which is 2.4 square kilometers (0.9 square miles) in size and has a mean depth of 9.8 meters (32 feet). The shorelines of Portage Bay and Lake Union are highly developed with numerous marinas, commercial shipyards, and house boat communities. The Fremont Cut is a steep riprap channel that connects Lake Union to Salmon Bay. There are 24 known nonnative fish species in the Lake Washington watershed (WSCC 2001).

Lower Green River foraging, migration, and overwintering habitat. The Green/Duwamish River watershed originates in the Cascade Mountains approximately 48 kilometers (30 miles) northeast of Mount Rainier and flows into Puget Sound at Elliott Bay in Seattle (KCDNR and WSCC 2000). Historically, the White, Green, Black, and Cedar Rivers flowed into the Duwamish River, with a drainage basin of over 4,144 square kilometers (1,600 square miles). In the early 1900's, the White, Black, and Cedar Rivers were diverted to other systems, reducing the Green/Duwamish drainage current area to 1,440 square kilometers (556 square miles).

The basin can currently be divided into four physiogeographic parts: 1) the upper Green River consisting of the headwaters to the Howard Hanson Dam at river mile 64.5; 2) the middle Green River from Howard Hanson Dam to the Soos Creek confluence at river mile 32; 3) the lower Green River from Soos Creek confluence to the Black River confluence at river mile 11; and 4) the Duwamish River watershed below river mile 11. Annual precipitation within the watershed varies widely from 90 centimeters (35 inches) in Seattle to over 254 centimeters (100 inches) in the Cascade foothills.

The upper Green River watershed contains approximately 45 percent of the Green/Duwamish watershed area and includes the Sunday, Sawmill, Champion, Smay, and Charlie Creeks, and the North Fork Green River. In this area, the river flows west and northwest through densely forested and steep and narrow valleys. The upland vegetation is a checkerboard of old-growth, second-growth, and recently logged areas. Immediately downstream of the North Fork Green River confluence at river mile 64.5 is Howard Hanson Dam, constructed in 1961 as a flood control facility. A well field, operated by Tacoma Public Utilities, is located in the North Fork Green River. Within the middle Green River watershed, a water supply diversion facility that blocks anadromous fish migration is maintained at river mile 61. Downstream of the diversion, the river flows through mostly forested, steep and narrow valleys to approximately river mile 46.4. At this point, the river flows through a largely forested, broad and gently sloped valley. The lower Green River watershed flows through increasingly urbanized areas within the cities of Auburn, Kent, and Tukwila. The mean annual flow in the lower Green River near Auburn is 1,350 cubic feet per second. Downstream of the Black River confluence at river mile 11, which is the upstream limit of tidal influence, the Green River is called the Duwamish River. The Duwamish River flows through a heavily industrialized area, scattered with urban parks and residences. The Duwamish River and Elliott Bay have been extensively modified, including the filling of 97 percent of their original wetlands and shallow subtidal habitats.

Lower Nisqually River foraging, migration, and overwintering habitat. The Nisqually River foraging, migration, and overwintering habitat consists of the Nisqually River estuary, McAllister Creek, and lower Nisqually River. The Nisqually River basin drains a total of 1,339 square kilometers (517 square miles) of land (USGS 1969) and has the largest estuary in south Puget Sound (Nisqually EDT Work Group 1999). Although the Nisqually River estuary is considered to be largely undisturbed, it has been modified by dikes and reduced in size by approximately 30 percent (Glass and Salminen 2002). The Nisqually River originates from glaciers and streams on the south side of Mount Rainier in the National Park and flows westerly to Alder Reservoir created by Alder Dam. Downstream of Alder Dam is LaGrande Dam from which the river flows northwesterly to south Puget Sound. LaGrande Dam, located at river mile 42.5 and completed in 1910, limits anadromous fish migration. A natural barrier may have historically existed near the location of this dam. Tributaries to the Nisqually River located below LaGrande Dam contribute approximately 40 percent of the total flow in the lower mainstem of the Nisqually River (Glass and

Salminen 2002). These tributaries include Muck Creek, Murray Creek, Toboton Creek, Tanwax Creek, Powell Creek, Ohop Creek and the Mashel River.

The majority of the basin is below 305 meters (1,000 feet) in elevation (Glass and Salminen 2002). The geology of the Nisqually River includes the lowlands (floodplains and terraces) and U-shaped glaciated mountains. The western portion of the watershed is covered by unconsolidated glacial deposits, while the eastern portion generally consists of sedimentary and volcanic rock. Mean temperature ranges from 1.1/7.8 degrees Celsius (34/46 degrees Fahrenheit) in winter to 8.3/15.5 degrees Celsius (47/78 degrees Fahrenheit) in summer. Mean annual precipitation within the watershed ranges from 84 to 127 centimeters (33 to 50 inches) in the lower watershed to 178 centimeters (70 inches) in the upper watershed. The wettest months are November through January, with June through August being the driest months. Natural vegetation includes western hemlock, western red cedar, Douglas fir, prairies, and some oak (*Quercus* spp.) woodland.

The McAllister subbasin includes McAllister Creek, and its tributaries, Medicine Creek, and Little McAllister Creek (Glass and Salminen 2002). McAllister Creek is a low gradient stream originating at McAllister Springs and flowing 8.8 kilometers (5.5 miles) to enter the Nisqually River delta southwest of the mouth of the Nisqually River.

Land use within the Nisqually Basin is diverse. The estuary is largely under Federal, Tribal, and State ownership. The lower Nisqually River is under Tribal and military ownership (Nisqually EDT Work Group 1999). The Nisqually River is bordered on the south bank by The Nisqually Indian Reservation from approximately river mile 3.7 to 10.6. The Fort Lewis Military Reservation borders the Nisqually River on the north bank from river mile 2.4 upstream to approximately river mile 21.0. The lower portion of the basin is primarily rural residential (49 percent), followed by forest (22 percent), forest/prairie (18 percent), and agriculture (4 percent), while the upper part is primarily forested (Glass and Salminen 2002). Two anadromous fish hatchery facilities currently operate within the Nisqually Basin.

Marine foraging, migration, and overwintering habitat. The "marine" foraging, migration, and overwintering habitat includes portions of Puget Sound and associated nearshore and estuarine areas. Puget Sound can be subdivided into five regions: 1) North Puget Sound; 2) Main Basin; 3) Whidbey Basin; 4) South Puget Sound; and 5) Hood Canal (NMFS 2000). The Hood Canal basin is part of the Olympic Peninsula Management Unit and is not discussed in this volume. The average depth of Puget Sound is 62.5 meters (205 feet) at mean low tide, the average surface water temperature is 12.8 degrees Celsius (55.0 degrees Fahrenheit) in summer and 7.2 degrees Celsius (44.0 degrees Fahrenheit) in winter (Staubitz *et al*. 1997). Estuarine circulation in Puget Sound is driven by tides, gravitational forces, and freshwater inflows. Significant variability in tidal heights occurs throughout Puget Sound. The major sources of freshwater are the Skagit and Snohomish Rivers located in Whidbey Basin. Fresh water flows into the Sound at an average rate of 4 billion cubic meters (140 billion cubic feet) per year. On average, the waters of Puget Sound are effectively replaced twice a year.

Nearshore and estuarine habitats are highly productive due to the complexity of habitats and nutrient inputs. Tidelands, salt marshes, sand- and mud flats, blind tidal channels, eelgrass, kelp and intertidal algal beds and marine shoreline areas within the photic zone are examples of nearshore and estuarine habitat (STAG 2002). Kelp beds and eelgrass meadows cover the largest area of Puget Sound, almost 1,000 square kilometers (386 square miles) (NMFS 2000). Other major habitats include subaerial and intertidal wetlands (176 square kilometers; 68 square miles), and mudflats and sandflats (246 square kilometers; 95 square miles). The extent of some of these habitats has markedly declined over the last century. The nearshore habitat of Puget Sound has been modified by channelization, bank protection and land use in the estuarine zone. Overall losses since European settlement, by area, of intertidal habitat is estimated to be 58 percent for Puget Sound (Hutchinson 1988). The Duwamish, Lummi, Puyallup, and Samish river deltas have lost greater than 92 percent of their intertidal marshes (Simenstad *et al*. 1982; Schmitt *et al*. 1994). Substantial declines of mudflats and sandflats have also occurred in the deltas of these estuaries (Levings and Thom 1994).

The North Puget Sound region is demarcated to the north by the United States-Canadian border, to the west by a line due north of the Sekiu River, to the south by the Olympic Peninsula, and to the east by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island and the mainland between Anacortes and Blaine, Washington (NMFS 2000). The region is bordered primarily by rural areas with a few localized industrial developments (PSWQA 1988). About 71 percent of the area draining into North Sound is forested, 6 percent is urbanized, and 15 percent is used for agriculture. The main human population in this area centers around Port Angeles (2000 population census: 18,397), Port Townsend (8,334), Anacortes (14,557), and Bellingham (67,171). An estimated 21 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Eelgrass is the primary vegetation in the intertidal areas of the Strait of Juan de Fuca, covering on average 42.2 percent (range 15 to 69.4 percent) of the intertidal area, and green algae is the second most common, covering on average 4.4 percent (range 0.7 to 8.1 percent) of the intertidal area (Bailey *et al*. 1998). About 45 percent of the shoreline of this region consists of kelp habitat, compared to only 11 percent of the shoreline of the other four Puget Sound regions (Shaffer 1998). Eelgrass is found in protected areas, such as Samish and Padilla Bays, while the densest kelp beds in Puget Sound are found in the Strait of Juan de Fuca.

The 75 kilometer (47 mile) long Main Basin is delimited to the north by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island, to the south by Tacoma Narrows, and to the east by a line between Possession Point on Whidbey Island and Meadow Point (near Everett) (NMFS 2000). The Main Basin includes Sinclair and Dyes inlets, Colvos and Dalco passages and the large embayments, Elliott and Commencement Bays. Approximately 30 percent of the freshwater flow into the Main Basin is derived from the Skagit River. Seattle, Tacoma, and Bremerton border the Main Basin. Human population sizes for these cities are about 563,374, 193,556, and 37,259, respectively (2000 census). Approximately 70 percent of the drainage area in this basin is forested, 23 percent is urbanized, and 4 percent is used for agriculture (Staubitz *et al*. 1997). An estimated 52 percent of the shoreline in this area has been modified by human activities (WDNR 1998). The Main Basin has a relatively small amount of intertidal vegetation, with an average of 28.3 percent (range 17.9 to 38.7 percent) of the intertidal area containing predominantly green algae and eelgrass vegetation (Bailey *et al*. 1998). Most of the eelgrass is located on the western shores of Whidbey Island and the eastern shores of the Kitsap Peninsula (PSWQA 1987).

The Whidbey Basin includes the marine waters east of Whidbey Island and is delimited to the south by a line between Possession Point on Whidbey Island and Meadowdale, west of Everett. The northern boundary is Deception Pass at the northern tip of Whidbey Island (NMFS 2000). The Skagit River (the largest single source of freshwater in Puget Sound) enters the northeastern corner of the Basin, forming a delta and the shallow waters (less than 20 meters; 66 feet) of Skagit Bay. Most of the Whidbey Basin is surrounded by rural areas with low human population densities. About 85 percent of the drainage area of this Basin is forested, 3 percent is urbanized, and 4 percent is in agricultural production. The primary urban and industrial center is Everett, with a population of 78,000. Most waste includes discharges from municipal and agricultural activities and from a paper mill. An estimated 36 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Vegetation, predominantly green algae, eelgrass, and salt marsh, covers an average of 23.6 (range 14.8 to 32.4 percent) of the intertidal area of the Whidbey Basin (Bailey *et al*. 1998). Eelgrass beds are most abundant in Skagit Bay and in the northern portion of Port Susan (PSWQA 1987).

The Southern Basin includes all waterways south of Tacoma Narrows (NMFS 2000). This basin is characterized by numerous islands and shallow (generally less than 20 meters; 66 feet) inlets with extensive shoreline areas. The largest river entering the basin is the Nisqually River which enters just south of Anderson Island. About 85 percent of the area draining into this basin is forested, 4 percent is urbanized, and 7 percent is in agricultural production. The major urban areas around the South Sound include Tacoma, University Place, Steilacoom, and Fircrest, with a combined population of about 100,000. Other urban centers in the South Sound Basin include Olympia with a population of 41,000 and Shelton with a population of 7,200. An estimated 34 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Among the five regions of Puget Sound, the Southern Basin has the least amount of vegetation in its intertidal area (average of 12.7 percent coverage, range 0 to 28.2 percent), with salt marsh (average of 9.7 percent coverage, range 0 to 24.4 percent) and green algae (average of 2.1 percent coverage, range 0.2 and 4 percent) being the most common types (Bailey *et al*. 1998).

DISTRIBUTION AND ABUNDANCE

Status of Bull Trout at the Time of Listing

In the final listing rule (64 FR 58910), we identified 16 bull trout subpopulations[†] in the area now delineated as the Puget Sound Management Unit of the Coastal Puget Sound Distinct Population Segment: Chilliwack River-Selesia Creek, lower Nooksack River, upper Middle Fork Nooksack River, Canyon Creek, lower Skagit River, Gorge Reservoir, Diablo Reservoir, Ross Reservoir, Stillaguamish River, Snohomish River-Skykomish River, Chester Morse Reservoir, Sammamish River-Issaquah Creek, Green River, lower Puyallup, upper Puyallup River, and Nisqually River (USFWS 1999). We considered five of these subpopulations to be depressed, one strong, and the remaining were of undetermined status. Habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, harvest, and introduced nonnative species were identified as the greatest threats to bull trout in the Puget Sound Management Unit. Although subpopulations were an appropriate unit upon which to base the 1999 listing decision, this recovery plan has revised the biological terminology to better reflect both our current understanding of bull trout life history and conservation biology theory. Therefore, subpopulation terms will not be used in this plan. Instead, recovery of the bull trout will be based on bull trout "core areas" as described above in Part I, Recovery Plan Terminology and Structure.

Current Distribution and Abundance

Bull trout are distributed throughout most of the large rivers and associated tributary systems within the Puget Sound Management Unit (WDFW 1998). With the probable exception of the Nisqually River, where only a few observations have been reported in the recent past, bull trout continue to be present in nearly all major watersheds where they likely occurred historically in this management unit. Generally, bull trout distribution has contracted and abundance has declined in the southern part of the management unit. Bull trout in this management unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous, or technically the “amphidromous” life history form is unique to the Coastal-Puget Sound Distinct Population Segment. Unlike strict anadromy, amphidromus individuals often return seasonally to freshwater as subadults, sometimes for several years, before returning to spawn (Wilson 1997). Anadromous bull trout have been documented throughout the current distribution within the management unit, and it is believed that fluvial forms are present in most populations as well. There are two naturally occurring adfluvial bull trout populations within the management unit; one is associated with Chester Morse Lake in the upper Cedar River drainage, and the other is associated with Chilliwack Lake in the upper Chilliwack River drainage. Prior to modification of Baker Lake in the Skagit River system, it is unknown to what degree the adfluvial life history was naturally expressed by bull trout in the Baker River watershed. As a result of dam construction, adfluvial populations now exist in Gorge, Diablo, and Ross Lakes in the upper Skagit River drainage.

There are currently a total of 59 local populations distributed among the eight identified core areas (Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse Lake, Puyallup). Nine additional local populations where identified in the portions of the Chilliwack and Upper Skagit core areas that extend into British Columbia. The recovery team also identified five potential local populations[†], one in the Upper Skagit core area, two in the Lower Skagit core area, one in the Chester Morse Lake core area, and one in the Puyallup core area. A potential local population is defined as a local population (a group of bull trout that spawns within a particular stream or portion of a stream system) that likely exists but has not been adequately documented, or that is likely to develop in the foreseeable future. Development of a local population is likely to occur if spawning habitat or connectivity is restored in that area or if bull trout recolonize or are reintroduced in an area. A population identified as a potential local population is considered necessary for recovery.

Bull trout and Dolly Varden are known to occur together only within the area of the Coastal Puget Sound Distinct Population Segment and in British Columbia, Canada. Although these two species of native char were previously considered a single species, the bull trout and the Dolly Varden have now been formally recognized as two separate species for many years (Cavender 1978; Robins *et al*. 1980; Bond 1992). Currently, genetic analyses can distinguish between the two species (Crane *et al*. 1994; Baxter *et al*. 1997; Leary and Allendorf 1997). Although morphometrics (measurements) and meristic variation (variation in characters that can be counted) can also be used successfully to distinguish the two species (Haas and McPhail 1991), there can be significant error associated with the application of this methodology by improperly trained users (Haas and McPhail 2001). Haas and McPhail (2001) determined that bull trout were much more likely to be misidentified as Dolly Varden (48 percent of the time), than Dolly Varden were to be misidentified as bull trout (2.5 percent of the time) when this methodology was applied. In the Puget Sound Management Unit, Dolly Varden have been confirmed only in the Upper Skagit and Nooksack core areas (McPhail and Taylor 1995; Spruell and Maxwell 2002). Although hybridization resulting in fertile offspring has been documented between the two species in other parts of their range, they appear to be able to maintain distinct genomes (Baxter *et al*. 1997), indicating they can coexist together. It has been hypothesized that resulting hybrids are selected against because they are intermediate in their behavior, ecology and morphology, and therefore cannot compete effectively against their parental forms (McPhail and Taylor 1995). McPhail and Taylor (1995) noted that upper Skagit River Dolly Varden, which are generally a stream resident, small in size, and drift feeders, predominate in tributary streams. In contrast, bull trout are migrants, much larger in size and piscivorous, and appear to predominate the main rivers. Current evidence suggests that the Dolly Varden in Washington tend to be distributed as isolated tributary populations above natural anadromous barriers, while bull trout are distributed below these barriers and are often anadromous (WDFW 1998; Spruell and Maxwell 2002). Dolly Varden may also be present in the Lower Skagit core area, but this has not been confirmed. In all other core areas within the management unit, only bull trout have been identified genetically. Based on the this information, all native char observed in accessible anadromous reaches are believed to be bull trout.

Anadromous and fluvial life history forms of bull trout typically have widely distributed foraging, migration, and overwintering habitat. In freshwater, important forage includes loose salmon eggs, salmon fry and smolts, sculpins, whitefish, and other small fish. Foraging juvenile and subadult bull trout can migrate throughout a core area looking for these feeding opportunities. Freshwater foraging habitat may be found anywhere in the core area downstream of spawning areas (local populations) and accessible to anadromous salmonids. Bull trout also use nonnatal watersheds to forage, migrate, and potentially overwinter. In marine waters, the principal forage is surf smelt and other small schooling fish (*e.g.*, sandlance, herring). Although foraging bull trout may tend to concentrate in forage fish spawning areas, they can be found throughout accessible estuarine and nearshore habitats. The maintenance of these prey species and marine foraging areas is key to maintaining the anadromous life form.

For most areas in the Puget Sound Management Unit, both freshwater floodplain habitats and tidally influenced areas are believed to play an important role in maintaining fluvial and anadromous populations of bull trout. Juvenile bull trout, particularly young-of-year, have very specific habitat requirements. In large rivers, the highest abundance of juveniles can be found near rocks, along the stream margin, or in side channels (Pratt 1984, 1992; Goetz 1994). Juveniles show preferential use of side channels based on their size and the distance from their point of emergence with fry using smaller side channels, age 1+ fish using slightly larger channels within natal streams, while age 2+ and age 3+ juveniles can be found at a significant distance from natal areas in moderate to large off-channel habitat areas in larger streams and major rivers. These areas may exhibit extremely high concentrations of older juveniles and subadults. In a comprehensive summer survey of all tributary rearing areas in the Metolius River basin, Oregon, the highest density of age 2+ and age 3+ juvenile bull trout was found at night in a wall-based channel (channel, often spring-fed, located near the base of a valley wall). This channel flowed into a beaver pond complex. Over 30 juvenile bull trout were found close to the confluence of the springs feeding the pond. No juvenile bull trout were observed in this area during a daytime survey (Goetz 1994).

Migratory (fluvial, adfluvial, and anadromous) bull trout use of off-channel habitats in floodplain areas (freshwater and tidally influenced) has been little studied in larger mainstem rivers. Prior to 2002, reports of bull trout use of floodplain habitats in western Washington were generally unavailable. However, recent review of the grey literature (primarily agency reports) and personal contacts shows that there is increasing information available demonstrating subadult and adult bull trout use of lower elevation floodplain habitats in freshwater and tidally influenced areas. In the Hoh River (Olympic Peninsula Management Unit), the highest concentration of spawning bull trout was found in a side channel in a reach of the upper river (S. Brenkman, Olympic National Park, pers. comm. 2001). Further downstream, three subadult bull trout were observed at the outlet to a wall-based pond complex in May and within the pond complex in August (Goetz, *in litt*. 2003a). The outlet of this pond had just been restored for fish passage in the previous months. In April 2000, in the Chehalis River basin, a single subadult bull trout was captured in a tidal slough restoration site near Ann's Slough (Jeanes *et al*. 2003). In the Puget Sound Management Unit, other observations of bull trout use of freshwater floodplain areas have been recorded in the lower end of the South Fork Nooksack River. These include the Black Slough (Nooksack Tribe, *in litt*. 2002), an unnamed South Fork slough (WDFW, *in litt*. 1994), and a mainstem Nooksack River side channel having combined flow from Anderson Creek (Nooksack Tribe, *in litt*. 2003). Use has also been recorded in the North Fork Nooksack River, where spring-fed waters enter a Glacier Creek overflow channel (B. Green, U.S. Forest Service, pers. comm. 2003); the North Fork Stillaguamish River, in a slough at the mouth of McGovern Creek; the Skagit River; and in the Upper Skagit, at Park and Newhalem Sloughs near Newhalem (USFWS, *in litt*. 2003). In tidally influenced floodplain areas of Puget Sound, subadult bull trout have been observed or captured in restored (3 locations) and natural tidal channels (2 locations), and larger distributary channels. These include the South Fork of the lower Skagit River, in Deepwater Slough, a moderate-sized tidal channel in a floodplain area previously isolated from the river and tides until reconnection occurred in October 2000 as part of a estuary restoration project (J. Klochak, Skagit System Cooperative, pers. comm. 2002); the Snohomish River, in two small tidal channels off Ebey Slough, a large distributary channel (Rowse, *in litt*. 2002); the Snohomish River, in Union Slough, in the spring of the year immediately following dike removal and restoration of a previously isolated floodplain area on Spencer Island (Tanner *et al*. 2002); the Skagit River, where adult and subadult bull trout have been recorded migrating through both forks during upstream and downstream migratory movements (Goetz, *in litt*. 2003b); and the Snohomish River, where subadult and adult bull trout have used portions of all three distributary channels (*i.e.*, Union, Steamboat, and Ebey Sloughs) in upstream and downstream migratory movements during spring, summer and fall, 2002 (Goetz, *in litt*. 2003b).

Regarding abundance, we must emphasize that there are currently no data to confidently estimate bull trout abundance for the entire management unit. However, a few core areas have been monitored through redd counts and adult counts at a level where estimates can be made at the local population or core area level. It is important to note that current data on distribution and abundance in the Puget Sound Management Unit is limited and has been collected by a variety of methods. Sources of data include historical reports, incidental bull trout counts obtained during other fish surveys, smolt and adult trap counts, creel survey data, redd count data, and adult counts. It is likely that spawner distribution and abundance is underestimated, and that some spawning and rearing areas have not been located and thus have been omitted. As new information on core areas is gathered, it will be used to update distribution and abundance information described below.

Chilliwack core area. The Chilliwack core area is delineated around those portions of the Chilliwack River and its major tributaries (Silesia Creek, Tomyhoi Creek, and Sumas River) contained within the United States (Figure 3). However, a significant portion of the Chilliwack River drainage lies within Canada and is functionally part of this core area. It is a transboundary system that flows from the United States northwest into British Columbia where it discharges into the lower Fraser River. Those reaches of the Chilliwack River and Silesia Creek (spelled “Slesse” in Canada) within the United States are contained within North Cascades National Park and the Mount Baker Wilderness, respectively. The short section of the Chilliwack River extending from the United States-Canada border up to and including Chilliwack Lake is within the boundaries of Chilliwack Lake Provincial Park in British Columbia. Although Chilliwack Lake

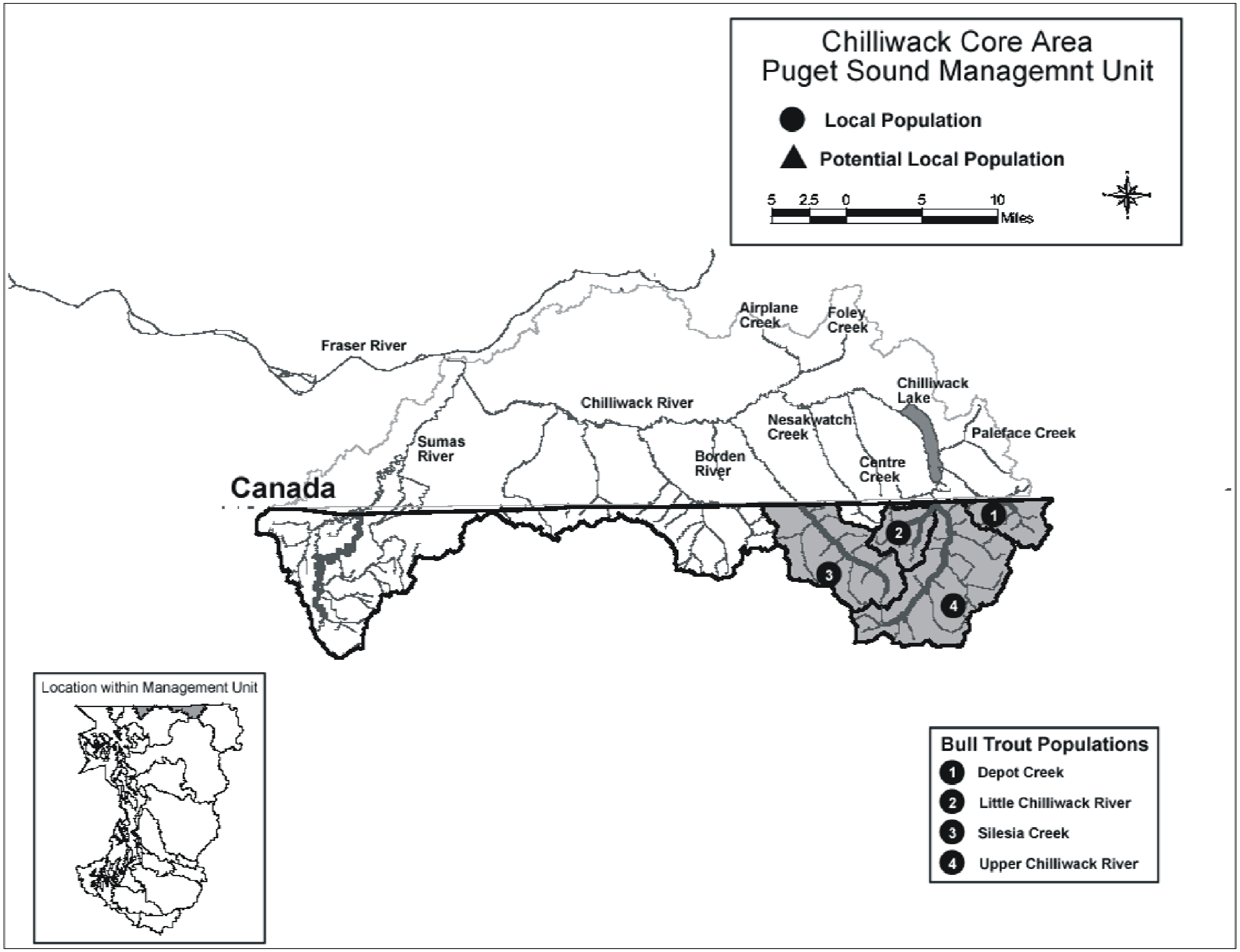

Figure 3. Chilliwack core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

is now entirely within the Chilliwack Lake Provincial Park, two of its major tributaries, Paleface and Depot Creeks, are extensively outside of the provincial park boundary with the exception of their lower reaches. The headwater reaches of Depot Creek fall within North Cascades National Park in the United States. Silesia Creek and Tomyhoi Creek (spelled “Tamihi” in Canada) and one of its tributaries, Damfino Creek, initiate from the Mount Baker Wilderness in the United States, eventually entering the Chilliwack River downstream of Chilliwack Lake. The Chilliwack River flows west eventually becoming the Vedder River, where it is then joined by the Sumas River (at Vedder Canal) before discharging into the Fraser River. In British Columbia, the status of the Chilliwack River stock of bull trout is categorized as at “presumed conservation risk” (*i.e.*, current threats are believed to be significantly affecting the population or the population is considered to be at risk) (BCMWLAP 2002).

Samples collected from Chilliwack Lake have been identified as bull trout based on genetic analysis, although Dolly Varden are also known to exist within the Fraser River system (Nelson and Caverhill 1999). The bull trout within the Chilliwack system are believed to express fluvial, adfluvial, and potentially resident and anadromous life histories (D. Jesson, Ministry of Water, Land and Air Protection, pers. comm. 2002a). An isolated resident population of native char has also been identified in Tomyhoi Creek; however, it has not been determined whether these are bull trout or Dolly Varden. Since this population is isolated above a complete anadromous barrier (Teskey, *in litt*. 1986), it may be designated as a separate core area in the future if these native char are determined to be bull trout. This population is currently believed to be Dolly Varden based on their isolation above a natural barrier, which is a comparable situation to Dolly Varden populations found in the upper Skagit and Nooksack Rivers. Tomyhoi Creek and one of its tributaries, Damfino Creek, initiate from the Mount Baker Wilderness in the United States and flow northwest into Canada.

An extensive survey effort for bull trout has not yet occurred within the upper Chilliwack River system, making it difficult to estimate spawner abundance for this core area (R. Glesne, National Park Service, pers. comm. 2002). However, limited survey efforts have helped determine distribution and the identification of current local populations (M.A. Whelen and Associates Ltd. and

TSSHRC 1996; Nelson and Caverhill 1999; Doyle *et al*., *in litt*. 2000). A total of three local populations, Upper Chilliwack River (which includes Easy, Brush, and Indian Creeks), Little Chilliwack River, and Selesia Creek have currently been identified in the U.S. portion of this core area, with seven additional local populations (Paleface Creek, Depot Creek, Airplane Creek, Foley Creek, Borden Creek, Centre Creek, and Newakwatch Creek) identified within British Columbia. The upper extent of bull trout spawning and rearing use in Depot Creek is currently uncertain since neither fish nor habitat surveys have been conducted in reaches within the United States. Accessible habitat occurs upstream as far as the United States-Canada border (M.A. Whelen and Associates Ltd and TSSHRC 1996), while topographic maps indicate approximately 3.2 kilometers (2 miles) of additional accessible habitat upstream of this point.

In the upper Chilliwack River, rearing bull trout (juveniles) have been observed in the mainstem Chilliwack River from Chilliwack Lake upstream to approximately Easy Creek (R. Glesne, pers. comm. 2002). Limited spawning has also been documented in the mainstem of Chilliwack River above Chilliwack Lake (Doyle *et al*., *in litt*. 2000), and suitable spawning habitat in the mainstem is believed to span from approximately 3.2 kilometers (2 miles) above Chilliwack Lake upstream to an area just above Easy Creek (R. Glesne, pers. comm. 2002). Accessible habitat on the mainstem Chilliwack River ends approximately 3.2 kilometers (2 miles) upstream from Easy Creek, near the confluence with Copper Creek. In 1999, a bull trout was observed in Indian Creek during limited National Park Service surveys (Doyle *et al*., *in litt*. 2000). Although bull trout were not observed within Bear Creek and Brush Creek during recent limited survey efforts, habitat in their lower reaches is clearly accessible and likely provides some spawning and rearing habitat. Bull trout were observed near the mouth of Bear Creek, within the lower reaches of Brush and Easy Creeks, and throughout Indian Creek in the mid 1970's (Glesne, *in litt*. 1993). Although native char presence has been documented in Little Chilliwack River, spawning has not yet been confirmed in this tributary (R. Glesne, pers. comm. 2002). The Little Chilliwack River is thought to be accessible to approximately river mile 6 and river mile 3.5 on its major tributary, the Little Fork, however, this has not been verified with field surveys (S. Zyskowski, National Park Service, pers. comm. 2003a). Habitat is essentially pristine, and likely supports some level of spawning. Spawning and rearing distribution is incomplete for Silesia Creek. Juvenile and young-of-year bull trout have been observed in British Columbia reaches, while spawning and rearing is assumed to extend upstream to all accessible reaches in the United States. It is unknown what proportion of the Silesia Creek population spawns within Washington, and since no population surveys have been conducted at this time, no estimates of abundance are currently available for this system.

In British Columbia, spawning is also believed to occur in Depot and Paleface Creeks based on the juvenile life stages (young-of-year and age 1+) that have been documented rearing in these streams (D. Jesson, pers. comm. 2002b). Individual estimates of adult abundance for Depot and Paleface Creeks are currently not available. However, creel census data for Chilliwack Lake can provide a conservative minimum combined estimate for these two local populations and the Little Chilliwack and Upper Chilliwack Rivers, assuming that the majority of bull trout captured in the lake spawn in one of these four systems. In 1998, a lake angler survey conducted by LGL Limited Environmental Research Associates estimated that 731 bull trout were captured during their May 23 to September 29 sampling period. It was noted, however, that a key spring fishery on bull trout that occurs in April and May was missed by the sample period, so overall annual catch may be significantly higher. Length-frequency distribution of bull trout sampled in the survey (n=166) show that 90 percent of those captured were greater than 350 millimeters (13.8 inches) in length (Nelson and Caverhill 1999). Assuming that bull trout equal to or greater than 350 millimeters (13.8 inches) are likely sexually mature, then approximately 658 mature adults were caught during the sample period. Based on this estimate, we believe the Depot Creek, Paleface Creek, Little Chilliwack River, and Upper Chilliwack River local populations support in aggregate at least 1,000 adult spawners annually, and the Chilliwack core area (excluding British Columbia local populations) could likely support a minimum of between 500 and 750 adult spawners when including the Selesia Creek local population. Habitat and spawner surveys need to be conducted on Selesia Creek to confirm this estimated potential spawner abundance and to determine the current spawner abundance in this local population.

The other local populations identified in British Columbia (Foley Creek, Borden Creek, Centre Creek, and Newakwatch Creek) are all tributaries to the mainstem Chilliwack River between Silesia Creek and the outlet of Chilliwack Lake. The exception is Airplane Creek, which is a major tributary to Foley Creek. Both young-of-year and age 1+ juvenile bull trout have been observed in all these tributaries (M.A. Whelen and Associates Ltd and TSSHRC 1996).

Migratory bull trout in this system spend all or part of their subadult and adult lives either in the mainstem of the Chilliwack River, Chilliwack Lake, and Fraser River. If anadromous forms exist in this population, they would also use nearshore waters of the Strait of Georgia. All of these areas provide foraging, migration, and overwintering habitat; however, Chilliwack Lake appears to be very important to the majority of local populations in this system. Both sockeye and kokanee use the lake to rear, and either the lake’s tributaries (kokanee) (Nelson and Caverhill 1999) or Upper Chilliwack River system (kokanee and sockeye) to spawn (Doyle *et al*., *in litt*. 2000; B. Fanos, Department of Fisheries and Oceans Canada, pers. comm. 2003), providing an important source of forage for bull trout in this part of the Chilliwack River basin. Migratory bull trout may potentially forage within the Sumas River and other tributaries that are accessible to migratory forms, but distribution and extent of use within these systems is not well known. Native char have been reported in the Sumas River tributary, Lonzo Creek, within British Columbia (Norecol, Dames & Moore, Inc. 1999). Although the Sumas River is a highly productive anadromous salmon system, it is unlikely that bull trout spawning or rearing occurs in the Sumas River or its tributaries given the relatively low elevation of this drainage.

Nooksack core area. The Nooksack core area consists of the Nooksack River and its tributaries, including the North, Middle and South Forks (Figure 4). The Nooksack River is the northernmost major river system draining directly to Puget Sound in the contiguous United States. The North and Middle Forks of the Nooksack River are glacially influenced, while the South Fork is fed primarily by snowmelt. The accessible lengths of many tributaries to the various river forks can vary over time, depending on where the active river channels are located within their channel migration areas, and the presence of intermittent passage blockages. Known spawning of bull trout occurs in all three forks of the

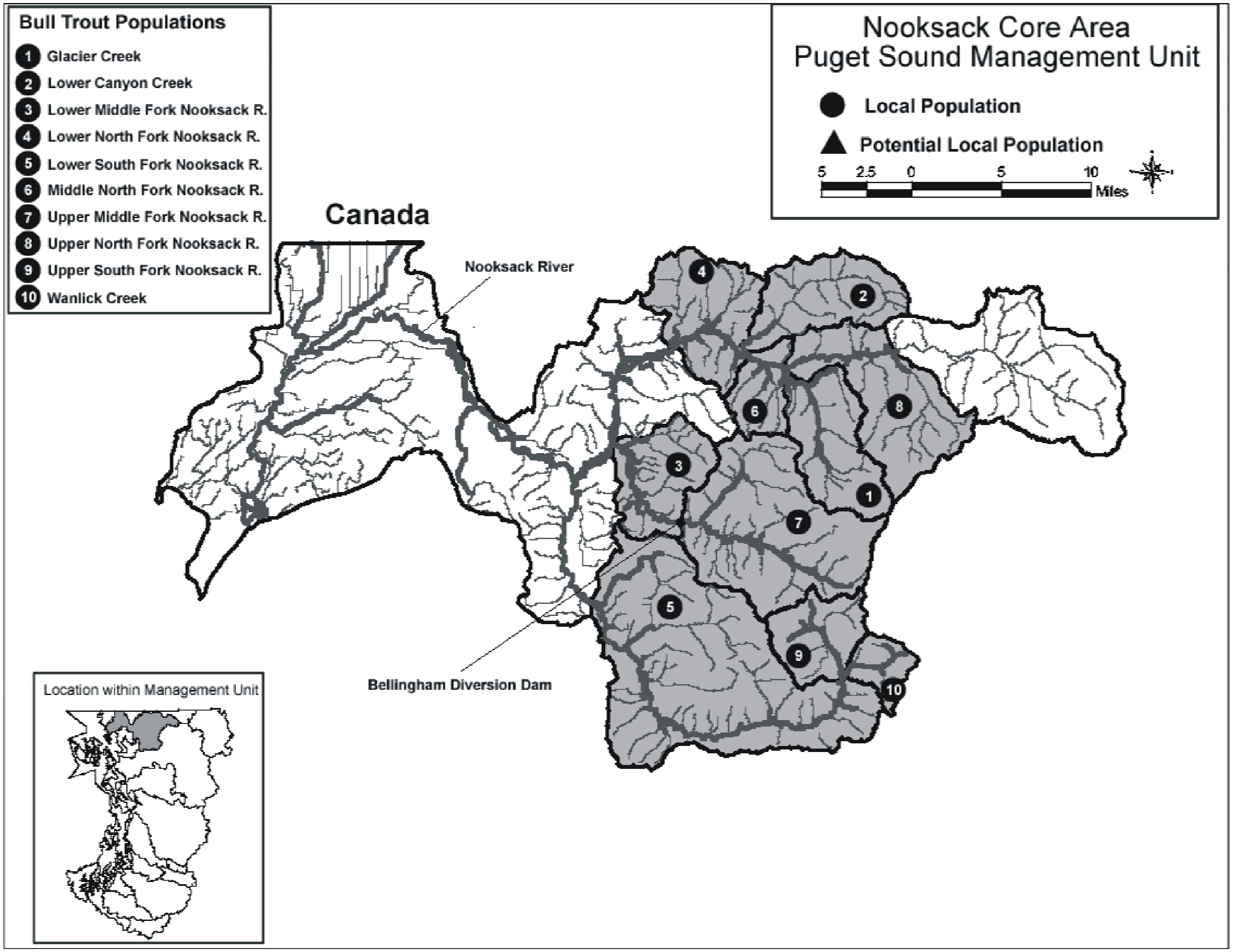

Figure 4. Nooksack core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

Nooksack River and in tributaries to them, while post dispersal rearing and subadult and adult foraging is believed to occur throughout the anadromous reaches. For example, juvenile to subadult sized bull trout (140 to155 millimeters; 5.5 to 6.1 inches) were recorded in lower Smith Creek and in lower Black Slough in November, 2001 (Nooksack Tribe, *in litt*. 2002). Overwintering likely occurs primarily in the lower mainstem reaches of the three forks and in the Nooksack River. The anadromous life history form is known to be present

(Lummi Nation, *in litt*. 2003; Maudlin *et al*. 2002), and fluvial and possibly resident life history forms also occur within this core area. Outmigrants have been caught in the lower mainstem from early April through mid-July. The anadromous life history form uses estuarine and nearshore marine areas in and near Bellingham Bay (Ballinger, *in litt*. 2000) and likely use areas further north and south of these areas similar to other anadromous populations.

The Nooksack core area contains populations of both bull trout and Dolly Varden, however there is currently an incomplete understanding about the level of interaction between the two species and degree of overlap in their distribution. Limited genetic analysis and observational data suggest Dolly Varden in this core area inhabit stream reaches above anadromous barriers. Native char collected from the Nooksack River within reaches currently or historically accessible to anadromous salmonids have been identified as bull trout, based on genetic analysis of a small number of samples collected from the upper South Fork (S. Young, Washington Department of Fish and Wildlife, pers. comm. 2003), and also on morphometric and meristic analysis by Dr. Gordon Haas of individuals collected in the upper Middle Fork (STS Heislers Creek Hydro L.P. 1994; M. Barclay, Framatome ANP, pers. comm. 2003). Genetic analysis of native char from an isolated resident population located upstream of a barrier falls in Canyon Creek (North Fork Nooksack River) determined them to be Dolly Varden (Leary and Allendorf 1997). Additional tissue samples collected from native char in upper Canyon Creek (upstream of barrier falls), one of its tributaries named Kidney Creek, and from a resident population in the South Fork headwater stream, Bell Creek (upstream of barrier falls), were also determined to be Dolly Varden (Spruell and Maxwell 2002). Additionally, genetic analysis of a small number of samples collected from a resident population in another tributary to the

South Fork Nooksack River, known as "Pine Creek," were determined to be Dolly Varden (Young, pers. comm. 2003).

Similar to the Chilliwack River basin, comprehensive spawning surveys have not been conducted within the Nooksack core area, although limited survey data were very recently collected by the Washington Department of Fish and Wildlife and U.S. Forest Service in a small number of streams. Data are not yet sufficient to estimate spawner abundances for the core area, but this and past observational data have helped define current local populations. A total of 10 local populations (Upper North Fork Nooksack River, Glacier Creek, Middle North Fork Nooksack River, Lower Canyon Creek, Lower North Fork Nooksack River, Upper Middle Fork Nooksack River, Lower Middle Fork Nooksack River, Upper South Fork Nooksack River, Wanlick Creek, and Lower South Fork Nooksack River) have currently been identified in this core area. While tributaries with known spawning and rearing are described, other unsurveyed, adjacent and accessible tributaries are probably utilized as well.

The North Fork Nooksack River provides approximately 45 kilometers (28 miles) of accessible habitat, ending at Nooksack Falls, which is located just upstream from the confluence with Wells Creek. The Upper North Fork Nooksack River local population includes the upper most accessible 11.9 kilometers (7.4 miles) of the North Fork Nooksack River, from Nooksack Falls to the confluence with Glacier Creek. Also included are the short, accessible portions of tributaries to the North Fork Nooksack River including Wells, "Powerhouse", Deadhorse, Cascade, "Ditch", Boyd, "Chain-up", and Deerhorn Creeks. Wells Creek is the only tributary that is glacially influenced. This reach of the river and these tributaries support bull trout spawning and rearing; short reaches of other tributaries may also be used, but this has not been confirmed. There is a single report from the mid 1980's of native char in the North Fork Nooksack River upstream from Nooksack Falls, above and below the confluence with White Salmon Creek, and within the lower part of this creek (Green, pers. comm. 2003). However, at this time no local population is designated above Nooksack Falls. Additional information is needed to determine if native char still persist above the falls, whether these are bull trout, and if so, their geographic distribution.

Intensive bull trout spawning surveys have not been conducted in the mainstem of the upper North Fork Nooksack River, however, it is considered to support some spawning and rearing based on a number of observations reported during irregular survey efforts. Large adult native char, believed to be bull trout, have been caught in the North Fork within a mile of the falls (D. Sahlfeld, Washington Department of Fish and Wildlife, pers. comm. 2002). It is currently unclear to what extent these fish are spawning in this relatively steep portion of the mainstem, or whether these fish are moving into Wells Creek to spawn. Pre-spawn staging adults were also observed nearly to Nooksack Falls in the 1970's (C. Kraemer, Washington Department of Fish and Wildlife, pers. comm. 2002). Norgore and Anderson (1921) caught a 305-millimeter (12-inch) native char 0.40 kilometer (0.25 mile) downstream of Nooksack Falls, and also caught advanced fry in backwater areas 2.4 kilometers (1.5 miles) downstream from the falls on June 27, 1921, indicating nearby spawning. In October of 2003, an adult bull trout in spawning coloration was caught immediately downstream from the confluence of Deadhorse Creek (N. Currence, Nooksack Tribe, pers. comm. 2003c).

Wells Creek is steep near its mouth, but is considered accessible to river mile 0.9, where a steep boulder cascades is present. Two bull trout redds were recorded during surveys conducted by the U.S. Forest Service and Washington Department of Fish and Wildlife between river mile 0.5 and 0.9 in 1993 (Huddle, *in litt*. 1995). Native char less than 305 millimeters (12 inches) in length were observed in lower Wells Creek in the early 1990's during surveys conducted by small hydropower applicants (FERC 1997). A Federal Energy Regulatory Commission report describes the lower Wells Creek as a sequence of alternating steep and low gradient (2 to 5 percent) reaches (FERC 1997) . Anecdotal information suggests that migratory size native char may have historically utilized Wells Creek upstream from river mile 0.9, prior to inner gorge landsliding, but recent surveys have only detected brook trout in the reaches upstream of this point (D. Huddle, Washington Department of Fish and Wildlife, pers. comm. 2002a; Zyskowski, pers. comm. 2002a). There is a 3.6-meter (12-foot) vertical falls that spills onto a mid-channel boulder at approximately river mile 1.7 (Huddle, pers. comm. 2002b), and it is considered unlikely that former anadromous use extended upstream from this point. "Powerhouse Creek" is a small, low gradient tributary which enters the river just downstream from the Excelsior hydroelectric powerhouse located below Nooksack Falls. Adult bull trout have been observed in the short 0.16- kilometer (0.1-mile) accessible portion of this creek, downstream of the impassible culvert that underlies the road leading to this facility (Huddle, pers. comm. 2002b). The creek gradient rapidly increases a short distance upstream of this road, presumably limiting available habitat above this point. Deadhorse Creek is accessible up to a steep cascade located at approximately river mile 0.1. Large bull trout adults and/or redds have been recorded in Deadhorse Creek during surveys conducted in 1982, 1992, 1993, 1994, 2001, and 2002, with a single day peak adult count of 8, and peak redd count of 14, both recorded in 1993 (Huddle, *in litt*. 1995; WDFW and USFS, *in litt*. 2001, 2002). Adult coho were also present during these surveys. The North Fork Nooksack River has recently recaptured the lower gradient, downstream portion of this creek, significantly reducing the amount of available spawning habitat. Cascade Creek is accessible to bull trout up to a falls located at approximately river mile 0.1. A large adult bull trout was observed downstream of the falls during fish surveys in 2001 (WDFW and USFS, *in litt*. 2001). "Ditch Creek" enters the North Fork Nooksack River downstream of Cascade Creek, and provides approximately 0.16 kilometer (0.1 mile) of accessible habitat. While adults or redds were not recorded during surveys in 2000 or 2001, adults and juveniles have been observed in past years at these locations (Huddle, pers. comm. 2002a, 2002b). Two age classes[†] of juvenile bull trout have also been observed in a river side channel immediately downstream of this creek, referred to as the Ditch Creek side channel (Huddle, pers. comm. 2002b). Spawning has also been observed in this side channel, upstream and downstream of "Ditch Creek", and this appears to correspond to periods when the creek's discharge is low (Huddle, pers. comm. 2002b). "Chainup Creek" has 0.2 kilometers (0.1 mile) of currently accessible habitat, and anadromous size bull trout have been observed spawning downstream of an impassible culvert on State Route 542 in the late 1990's (Sahlfeld, pers. comm. 2002). There is likely 0.40 to 0.80 kilometer (0.25 to 0.50 mile) of formerly accessible, suitable habitat upstream from this culvert (R. Nichols, U.S. Forest Service, pers. comm. 2002). This creek has year-round flow (Huddle, pers. comm. 2002b). Deerhorn Creek (stream catalog no. 0491) also has 0.16 kilometer (0.1 mile) of currently accessible habitat, and young-of-year juveniles have been observed downstream of the impassible culvert under

State Route 542 (Huddle, pers. comm. 2002b). This creek frequently goes subsurface during the summer, and the length of available habitat upstream of the culvert is thought to be short (Huddle, pers. comm. 2002b). Boyd Creek has approximately 0.48 kilometer (0.30 mile) of low gradient habitat, downstream of a falls. Anadromous size adults are recorded in this creek most survey years, with a single day peak of 5 adults counted in 1992, and a peak redd count of 16 in 1994 (Huddle, *in litt*. 1995). Adult coho were also present in the area during these surveys.

The Glacier Creek local population is heavily influenced by glacial runoff, but it has a number of non-glacial tributaries that support spawning and rearing for anadromous bull trout. The full extent to which spawning occurs in the Glacier Creek system is unknown, but anadromous size bull trout have been recorded spawning in Falls Creek, Coal Creek, and in small spring-fed tributaries, Thompson Creek, and Little Creek. Spawning probably occurs in Glacier Creek and several additional tributaries are considered likely to support bull trout spawning and rearing. These include an unnamed tributary (stream catalog no. 0476) which enters Glacier Creek at river mile 4.3, and Deep Creek (Huddle, pers. comm. 2002b; Nichols, pers. comm. 2002). Use is considered possible in Grouse Creek as well (Huddle, pers. comm. 2002b), and the presence of juveniles in Davis Creek (described below) indicates spawning here as well.

In 1982 and 1984, native char were the most common species collected in a proposed hydropower bypass[†] reach in Glacier Creek from approximately river mile 3.5 to 5.6 (FERC 1997). There is a falls on Glacier Creek at approximately river mile 3.4 where adult native char were observed jumping in 1981 (J. Schuett-Hames, Washington Department of Ecology, pers. comm. 1999). This potential barrier has now been determined to be passable, as a dead adult migratory-sized bull trout was recorded about 1.6 kilometers (1 mile) upstream of the falls following a flood event in 1989 (Zyskowski, *in litt*. 1989), and more recent observations of large adults and redds recorded in tributaries upstream. Falls Creek enters Glacier Creek at river mile 5.0, with spawning observed in the lower 0.32 kilometer (0.2 mile) (Huddle, pers. comm. 2002a; Zyskowski, pers. comm. 2002a). Two adults, 305 and 406 millimeters (12 and 16 inches) in length, and four redds were recorded from the mouth of Falls Creek up to river mile 0.2 in

1993 (Huddle, *in litt*. 1995), and one redd and two adults (518 and 569 millimeters; 20.4 and 22.4 inches) were recorded in 2002 (WDFW and USFS, *in litt*. 2002). Coal Creek enters Glacier Creek at river mile 4.7, and spawning adults have occasionally been observed in the lower portion of this creek, not far upstream of its confluence with Glacier Creek (Huddle, pers. comm. 2002b). A series of left bank, groundwater fed springs enter the Glacier Creek floodplain downstream of Coal Creek. Spawning has occasionally been observed in this area, including one redd located upstream from the U.S. Forest Service road crossing (Huddle, pers. comm. 2002b). Historical tractor logging resulted in skid trails which altered the surface hydrology in this area, eventually causing the road in this location to wash out. Rock groins (instream structures built to deflect flows and increase deposition[†] of sediment along stream banks), installed to protect the road, now impair access to this habitat (Huddle, pers. comm. 2002b).

Thompson Creek enters Glacier Creek at river mile 1.8, and it provides at least 2.7 kilometers (1.7 miles) of spawning and rearing habitat, with consistent records of anadromous adult bull trout and redds. Approximately 10 to 15 migratory size adults (11 to 13 kilograms; 5 to 6 pounds) were observed spawning in the lower 1.4 kilometers (0.9 mile) in the mid-1980's (Barclay, pers. comm. 2003). A single day peak count of 22 adults and 9 redds were recorded during spawn surveys in 2002 (WDFW and USFS, *in litt*. 2002). Bull trout use is presumed upstream from the passable cascade located at river mile 1.7 up to about mile 2.2 where a large waterfall blocks further passage (Zyskowski, pers. comm. 2003b). Spawning is presumed to occur in lower Davis Creek to approximately river mile 0.2 (Nichols, pers. comm. 2002). While spawn surveys have not been conducted, a substantial number of juvenile bull trout mostly 76 to 127 millimeters (3 to 5 inches) in length were observed in the mid-1980's during fish relocation efforts associated with a habitat improvement project. These bull trout were observed in lower Davis Creek where spring-fed waters enter an overflow channel in the Glacier Creek floodplain (Green, pers. comm. 2003). Little Creek is also believed to support spawning and rearing, as spawning bull trout were observed at river mile 0.1 in 1981 (Schuett-Hames, pers. comm. 1999).

The Middle North Fork Nooksack River local population includes the mainstem Nooksack River and associated tributaries between Glacier Creek and

Canyon Creek. Spawning information in the North Fork Nooksack River downstream of Glacier Creek is very limited. There is an anecdotal report of bull trout spawning in a side channel downstream of Glacier Creek (G. Dunphy, Lummi Nation, pers. comm. 2002). Bull trout redds have also been recorded in Cornell Slough. Tributaries that support bull trout spawning and rearing include Gallop Creek, an unnamed tributary to Gallop Creek, Cornell Creek, and Hedrick Creek.

Gallop Creek enters the North Fork approximately 0.3 kilometers (0.2 mile) downstream of Glacier Creek. An adult bull trout was recorded in 1993 and redds recorded in 1994 during spawning surveys to river mile 0.7 (Huddle, *in litt*. 1995). Additionally, large adults have been recorded during hook and line sampling at the base of the cascades at river mile 0.9 (Sahlfeld, pers. comm. 2002). A tributary referred to as “Son of Gallop” enters Gallop Creek upstream of State Route 542. Bull trout spawning was observed in the lower 0.1 mile of this creek in 1999 (Huddle, pers. comm. 2002a). Cornell Creek does not have recent records of bull trout, although native char were historically reported to use it (Norgore and Anderson 1921). Available habitat in Cornell Creek is limited by a 3.6-meter (12-foot) falls at about river mile 1.0 (Pautzke 1943). Mass wasting[†] has built up this creek’s alluvial fan[†], and in late summer, adult salmon enter on freshets then die when the creek becomes subsurface (Huddle, pers. comm. 2002a). The Cornell Slough complex includes the outlet of Bottiger’s Pond, Mink Farm Spring Creek, and lower Hedrick Creek. A dead adult bull trout and bull trout redds were recorded in this main slough in 1994 (Huddle, *in litt*. 1995). Adult bull trout have also been recorded in Hedrick Creek downstream of an impassible, double box culvert under State Route 542 (Huddle, pers. comm. 2002a). An examination of topographic maps suggests 1.6 kilometers (1 mile) of habitat may exist upstream of this culvert.

The Lower Canyon Creek local population consists of one of the largest known bull trout spawning tributaries in the North Fork Nooksack River. Canyon Creek is a very large, non-glacially influenced tributary, and with the exception of Glacier Creek, provides the greatest length of accessible habitat of all the North Fork bull trout spawning tributaries. Canyon Creek is used by stronger migrating salmonids including bull trout to about river mile 4.0. Spawning surveys for bull trout have generally not been conducted in this creek since it is difficult to survey, particularly in the upper reaches. However, U.S. Forest Service snorkel surveys recorded 12 adults (up to 610 millimeters; 24 inches) as well as juveniles in a 1989 survey of the 7.1-kilometer (4.4-mile) anadromous reach. All were observed upstream of a cascade located at river mile 1.3, with the largest adult located near the top of the reach (Zyskowski, *in litt*. 1991). Counts are believed to be incomplete since only 20 percent of pools and 10 percent of riffles were sampled during this survey. Pre-spawn staging adult bull trout have also been observed holding in a gorge pool downstream of a second cascade (river mile 2.0) during spring Chinook spawn surveys (Huddle, pers. comm. 2002a). Both pre-spawning and post-spawning adults were reported in lower Canyon Creek in the 1970's (Kraemer, pers. comm. 2002). Genetic analysis of native char in Canyon Creek, upstream from the complete barrier, determined the samples to be from Dolly Varden.

The Lower North Fork Nooksack River local population consists of the North Fork Nooksack River and tributaries between Canyon Creek and Maple Creek. Boulder Creek is likely the most important spawning tributary in the local population. Survey data are generally lacking, but known or presumed spawning areas are based on the geographic settings and the limited data that are available. Boulder Creek is a large non-glacially influenced stream, with anadromous access up to a falls located at approximately river mile 1.3. Eleven adult bull trout, believed to be staging prior to spawning, were observed in two pools near the upper extent of accessible habitat in 1987 (Johnston, *in litt*. 2000). These fish appeared to be between 432 to 559 millimeters (17 to 22 inches) in size. Two juveniles, 127 and 171 millimeters (5 and 6.75 inches) in length, were also caught near the upper extent of accessible habitat. No adult or juvenile bull trout were observed further downstream in the creek. Norgore and Anderson (1921) also listed native char among the salmonids that reportedly used lower Boulder Creek. While not surveyed, the accessible reaches of several north-facing tributaries including Wildcat, "McDonald", and "Aldrich" Creeks are presumed to support spawning and rearing (DaPaul, Inc. 1994). Adult bull trout have been observed in "McDonald Creek" (Huddle, pers. comm. 2002a). In Maple Creek, mature bull trout up to 457 millimeters (18 inches) in size have been observed, (Huddle, pers. comm. 2002a), and what are believed to be subadults were recorded in snorkel surveys in 2002 (Ecotrust, *in litt*. 2002). These observations are thought to be of foraging fish, attracted to the highly productive portion of Maple Creek downstream from the falls at river mile 0.8. Maple Creek is extensively surveyed for salmon, and consistent bull trout spawning would most likely have been observed incidental to these surveys. Other highly productive tributaries that are believed to support foraging for subadult and adult bull trout including the accessible reaches of Racehorse Creek, Bells Creek and its sloughs, and the "Bear Creek" slough complex and accessible portions of its tributary streams.

Similarly, adult bull trout have been observed at the Washington Department of Fish and Wildlife hatchery weir located near the mouth of Kendall Creek (Huddle, pers. comm. 2002a). This facility was constructed in 1899, and while anadromous fish are not passed upstream into Kendall Creek, this watershed is comparatively low elevation and may not have historically supported bull trout spawning. Adults have also been observed in Kenny Creek in 1994 or 1995 (Huddle, pers. comm. 2002a). It is unknown whether these are pre-spawning or foraging individuals, but an impassible road culvert at river mile 1.7 blocks access to habitat in the upper creek. There is also a baffled structure and perched culvert at the mouth of Kenny Creek that is a velocity barrier to all fish at high flows, and likely for smaller fish at normal discharges.

The Middle Fork Nooksack River is glacially influenced, with the lowest 10.9 kilometers (6.8 miles) transitioning upstream from a very low gradient braided channel to a more moderate gradient channel. The Middle Fork Nooksack River's average gradient is 2.4 percent over its lower 28 kilometers (17.4 miles), with no natural barriers to adult migration to at least river mile 17.8 (STS Heislers Creek Hydro 1994). At approximately river mile 6.8, the river exits from a 0.8-kilometer (0.5-mile) long bedrock gorge called Box Canyon. At its narrowest, the river is 2.7 meters (9 feet) wide in the gorge (Barclay, *in litt*. 1989). In 1987, a landslide temporarily blocked fish passage, although it was restored in a subsequent flood. No permanent features block passage through the gorge (Barclay, *in litt*. 1989). Norgore and Anderson (1921) also reported no falls greater than 0.9 meter (2.9 feet) high, and concluded there were no passage barriers. The City of Bellingham has an unladdered diversion dam located approximately 76 meters (250 feet) above the upstream entrance to the gorge.

Constructed around 1960, this dam is 3.6 to 4.3 meters (12 to14 feet) high and diverts water from the Middle Fork Nooksack River to Lake Whatcom. Salmon and trout, including bull trout, have been incidentally observed jumping at or over the diversion dam in 1986, 1992, and 1993 (STS Heislers Creek Hydro L.P. 1994; Currence 2000), and also in 2001 (Corral, *in litt*. 2001; E. Zapel, Northwest Hydraulics Consultants, pers. comm. 2001). A fisherman reported catching a 483 millimeter (19 inch) bull trout downstream of the Sven Larson Bridge (located upstream of the diversion dam) in the early 1990's (Huddle, pers. comm. 2002b). The size of this fish suggests it was anadromous. In October of 2000, two bull trout approximately 229 and 305 millimeters (9 and 12 inches) were caught less than 1.6 kilometers (1 mile) upstream from the mouth of its major tributary Clearwater Creek (J. Lee, Whatcom County, pers. comm. 2003). Since the diversion dam appears to stop most, but not all, migratory bull trout, the Middle Fork Nooksack River is presently separated into two local populations (Upper and Lower Middle Fork Nooksack River). When unimpeded anadromous passage is restored at the diversion dam, and as more information is collected, local populations may be revised (combined and/or subdivided). Several of these creeks such as Sisters Creek and Clearwater Creek contain substantial low gradient habitat upstream from steeper cascades that are probably only passable to anadromous bull trout, and abundances and usage is expected to change when full passage is restored. Comprehensive surveys have not been conducted in this fairly remote area.

The Upper Middle Fork Nooksack River local population includes more than 16.6 kilometers (10.3 miles) of mainstem and accessible tributary reaches above the diversion dam. The mainstem habitat is accessible to river mile 17.5, approximately 0.4 kilometer (0.25 mile) upstream of Ridley Creek. The reach between Wallace and Clearwater Creeks is the lowest gradient portion above the diversion dam, averaging 2 to 3 percent (STS Heislers Creek Hydro 1994). Spawning and rearing is reported or presumed in the Middle Fork mainstem, Ridley Creek, Rankin Creek, Green Creek, an unnamed tributary immediately upstream of Wallace Creek, Wallace Creek, Warm Creek, Sisters Creek, an unnamed tributary 1.6 kilometers (1 mile) downstream of Warm Creek, an unnamed tributary 0.3 kilometer (0.2 mile) upstream from Seymour Creek, Galbraith Creek, Clearwater Creek and Rocky Creek. Once anadromous access is restored and additional information collected, this local population may be further subdivided.

In 1993, five bull trout (98 to179 millimeters; 4 to 7 inches) were caught in the Middle Fork Nooksack River mainstem and side channels near river mile 13 during juvenile sampling efforts (STS Heislers Creek Hydro 1994). They were described as relatively common in the upper Middle Fork Nooksack River and apparently more abundant in upstream reaches. Two of these fish were submitted for morphometric and meristic analysis and were determined to be bull trout (STS Heislers Creek Hydro 1994; Barclay, pers. comm. 2003). Ridley Creek enters the Middle Fork Nooksack River near the upper limit of migratory access, and while unsurveyed, this creek is presumed to be used by bull trout for spawning and rearing. It is accessible and affords substantial low gradient, high quality habitat (Green, pers. comm. 2003). Rankin Creek has cascades located at about river mile 0.3, which were likely passable at high flows (WDF 1978). Topographic maps indicate 0.4 to 0.8 kilometer (0.25 to 0.5 mile) of usable habitat upstream from the cascades, which may be used presently or in the future by anadromous bull trout. Norgore and Anderson (1921) also reported advanced fry in a tributary between Green and Ridley Creeks, which they referred to as “Ward Creek,” indicating nearby spawning. This creek was most likely Rankin Creek. Green Creek has accessible habitat up to a three-meter (10-foot) falls located at river mile 0.5 (Norgore and Anderson 1921). A small number of resident size native char were observed spawning in the mid-1970’s in the lower reach of Green Creek which paralleled the Middle Fork Nooksack River (Kraemer, pers. comm. 2002). Spawning and rearing is also presumed in a low gradient tributary entering upstream of Wallace Creek that was described as paralleling the mainstem of the river for 0.6 kilometer (0.4 mile) (WDF 1978). Juvenile native char were also observed during electrofishing in the mid-1970’s in lower Wallace Creek (Kraemer, pers. comm. 2002), which has accessible habitat up to a falls located at river mile 0.2 (Nooksack Tribe, *in litt*. 2001).

A number of observations indicate spawning and rearing in Warm Creek below the falls located at about river mile 0.4. Norgore and Anderson (1921) reported catching advance native char fry, and Johnston (Washington Department of Fish and Wildlife, pers. comm. 1999a) found native char of all age classes in lower Warm Creek in 1991. Juvenile native char were also observed during electrofishing efforts in the mid-1970's in lower Warm Creek (Kraemer, pers. comm. 2002), and during surveys conducted in pursuit of development of a small hydroelectric facility (FERC 2002a). The lowest 0.16 kilometer (0.1 mile) of Warm Creek parallels the Middle Fork Nooksack River, occupying a former mainstem channel (Nooksack Tribe, *in litt*. 2001). Norgore and Anderson (1921) also reported native char in Sisters Creek. This creek has cascades near the mouth that are considered passable to large anadromous fish at higher flows, with accessible habitat up to a falls located at river mile 1.0 (Nooksack Tribe, *in litt*. 2001). Bull trout are presumed to use the lower 0.6 mile of an unnamed tributary entering about a mile downstream of Warm Creek. This unnamed creek provides good low gradient habitat for bull trout spawning and rearing. Another unnamed tributary entering the river 0.3 kilometer (0.2 mile) upstream of Seymour Creek has 0.48 kilometer (0.3 mile) of low gradient habitat (CES 1992), and has presumed use by spawning and rearing bull trout. An accessible unnamed low gradient tributary enters just upstream of Middle Fork road bridge at river mile 10, and spawning and rearing is presumed in approximately the lower 0.5 kilometer (0.3 mile).

In 1986, resident-sized native char were reported spawning in Clearwater Creek at about river mile 2.5 (Johnston, pers. comm. 1999a), with a total of 13 individuals hook and line sampled (13.3 to 28 centimeters; 5.25 to 11 inches) in the lower 5.6 kilometers (3.5 miles) of the creek. The lower reach of Clearwater Creek is low gradient, becoming relatively steep with several cascades upstream of river mile 0.3. The cascades are considered passable by anadromous fish (FERC 2002a). The lower 2.9 kilometers (1.8 miles) of Clearwater Creek average 5.3 percent gradient, diminishing to 3.8 percent up to river mile 3.6 with an impassible falls located just upstream of the confluence with Rocky Creek (Nooksack Tribe, *in litt*. 2001). Access continues up Rocky Creek, with additional low gradient habitat, the lower kilometer (0.6 mile) averaging 3.2 percent gradient.

The Lower Middle Fork Nooksack River local population includes spawning that occurs in the Middle Fork Nooksack River and accessible tributaries downstream of the diversion dam to the confluence with the North

Fork Nooksack River. Anadromous size pre-spawning and post-spawning adults were observed in the 1970's at the outlet of Box Canyon, and adults have been captured just downstream from the canyon (Kraemer, pers. comm. 2002). Spawning is presumed to occur in and downstream of the gorge. While not a complete barrier to anadromous fish, the diversion dam significantly impedes bull trout migration to upstream habitats. Juveniles were recently captured at approximately river mile 2.5 (Anchor Environmental, L.L.C., *in litt*. 2002). It is unknown whether these are progeny from local spawning or from the Upper Middle Fork Nooksack River local population. Norgore and Anderson (1921) mentioned that native char were reported to use Canyon Lake Creek. This creek is accessible up to a falls at river mile 1.25, but spawning or rearing has not been confirmed. Porter Creek has 1.6 kilometers (1.0 mile) of accessible habitat and frequently becomes subsurface across its alluvial fan during late summer. It is believed to currently provide only subadult and adult foraging habitat. Although similar to Canyon Lake Creek, spawning and rearing are considered possible in this tributary. Channel migration by the Middle Fork varies the length of available habitat, and in recent years the river has recaptured the lower portion of Porter Creek. "Peat Bog Creek" (stream catalog no. 0352) and "Bear Creek" (stream catalog no. 0353) that enters just downstream are productive, low gradient systems discharging into a mainstem side channel complex. It is believed that these areas provide habitat for foraging and potentially spawning and rearing. The unnamed tributary (stream catalog no. 0347) that enters just upstream of Canyon Lake Creek is also a low gradient and productive salmon stream, and bull trout are presumed to use the lower 3.2 kilometers (2 miles) for foraging.

The South Fork is non-glacial, and predominately very low gradient, although is has confined reaches at Dyes Canyon (river mile 16 to17), Sylvesters Canyon (river mile 25), and near river mile 30.5. Although Sylvesters Falls (river mile 25) is approximately 3.4 meters (11 feet) tall, the presence of very large adult bull trout and summer-run steelhead in the upper South Fork indicate that these falls, and the cascades at river mile 30.4, are passable to anadromous bull trout. Upstream from river mile 30.4 the river is again unconfined and low gradient up to its headwaters above Elbow Creek. The upper South Fork, while non-glacial, is fed from snowpack on Twin Sisters Mountain. Comprehensive bull trout spawning surveys have not been conducted in the South Fork.

The Upper South Fork Nooksack River local population includes the mainstem between river mile 34 and 39, the major unnamed tributary upstream of “Elbow Creek,” Bell Creek, and the accessible reaches of small tributaries between Bell and Wanlick Creeks. The upper limits of bull trout distribution have not been determined for most of these tributaries with the exception of “Pine” and Bell Creeks. Spawning and/or rearing is presumed to occur in all accessible areas of the mainstem and tributaries. Large adults have been observed up to about river mile 38 in the mainstem near the confluence with Elbow Creek (Zyskowski, pers. comm. 2003b). Norgore and Anderson (1921) caught native char in the same general area, 2.5 miles downstream from Elbow Lake. The South Fork is accessible to at least the confluence of the major unnamed tributary that lies upstream of Elbow Creek (Huddle, pers. comm. 2002b), and topographic maps indicate that the river and this tributary are both low gradient and unconfined for 0.8 kilometer (0.5 mile) or more. Spawning and rearing are presumed in these areas, and in the accessible portion of Elbow Creek. Large adults, presumed to be anadromous, were observed spawning in the South Fork near Bell Creek in the 1970’s (Kraemer, pers. comm. 2002). In the 1990’s tissue was collected from two fish (both approximately 200 mm) captured upstream of the 1260 bridge (approximately river mile 36) during night surveys (S. McGrath, Washington Department of Fish and Wildlife, pers. comm. 2003). Genetic analysis determined that these were bull trout, while the samples from an isolated population of resident char in a nearby tributary commonly referred to as “Pine Creek” were determined to be Dolly Varden (Young, pers. comm. 2003). Bell Creek has an impassible falls located at approximately river mile 0.25 (Green, pers. comm. 2003). Norgore and Anderson (1921) caught native char in Bell Creek, presumably downstream of these falls. Tissue samples from the resident native char population above the falls were determined to be Dolly Varden (Spruell and Maxwell 2002). Bull trout to 610 millimeters (24 inches) have also been observed during mainstem snorkel surveys at about river mile 36 (Zyskowski, pers. comm. 2003b), and two adult bull trout were observed during recent spawner surveys conducted from river mile 34.0 to 34.3 (WDFW and USFS, *in litt*. 2002).

The Wanlick Creek local population consists of Wanlick Creek and its accessible tributaries. Wanlick Creek is a major tributary to the upper South Fork Nooksack River. It is believed to support spawning and rearing to approximately river mile 4, and in Loomis and “Monument” Creeks. Three anadromous size bull trout were caught in Wanlick Creek, downstream of “Monument Creek,” during hook and line surveys (Huddle, pers. comm. 2002b). In 2002, an adult bull trout (approximately 711 millimeters; 28 inches) as well as multiple age classes of juveniles were observed during a snorkel survey of a small portion of the stream reach downstream of “Monument Creek” (Ecotrust, *in litt*. 2002). Loomis Creek has known use to approximately river mile 0.5, with presumed use up to river mile 1. Bull trout up to approximately 355 millimeters (14 inches) have been observed in Loomis Creek upstream from the U.S. Forest Service 12 road, with about a dozen adults (406 to 457 millimeters;16 to18 inches) observed in a single pool downstream of the road crossing (Zyskowski, pers. comm. 2002a, 2003b). A partial passage barrier exists under the U.S. Forest Service 12 road crossing. Age 0+ juveniles have been recently observed in lower Loomis Creek (Huddle, pers. comm. 2003a). “Monument Creek” also supports spawning and rearing, as juvenile age classes were observed during 2002 snorkel surveys (Ecotrust, *in litt*. 2002). The lower reaches of other tributaries to Wanlick Creek are presumed to also support bull trout spawning and rearing.

The Lower South Fork Nooksack River local population includes the mainstem and all tributaries downstream of Wanlick Creek, with Hutchinson Creek considered the downstream limit of spawning. Most streams have not been surveyed, and with more data this local population may be divided. A potential bull trout redd was observed in the first small stream that enters the South Fork Nooksack River downstream from Wanlick Creek (Salhfeld, pers. comm. 2002). Spawning bull trout have also been observed in the short accessible reach of the stream draining Bear Lake (Huddle, pers. comm. 2002a). Norgore and Anderson (1921) caught native char in lower Howard Creek downstream from the 1.8-meter (6-foot) falls at river mile 0.25. Bull trout can likely migrate past this falls to about river mile 1.0. Spawning is presumed in the other short accessible reaches of the other streams between Wanlick and Howard Creeks. It is undetermined how far downstream in the South Fork Nooksack River bull trout spawn, but temperatures elevate progressively downstream, with spawning likely limited to cooler tributaries. In 1994, a single juvenile was captured in the mainstem during minnow trapping efforts near river mile 30 (WDFW, *in litt*. 1994). Adult bull trout were observed in this same reach September 1990 and in September and October 1992, suggesting spawning occurs nearby (Huddle, *in litt*. 1995). A newly emergent young-of-year juvenile was caught near river mile 20, off the mouth of Deer Creek around spring of 2001 (Dunphy, pers. comm. 2002). Bull trout between 150 to 300 millimeters (6 to 12 inches) have been observed in the same general area, and in the Teather Hole side channel across from the mouth of Deer Creek. Deer Creek and Plumbago Creek are accessible up to high falls, each located about 0.8 kilometer (0.5 mile) upstream from their mouths. The accessible portion of Fobes Creek also has presumed use for approximately 0.6 kilometer (0.4 mile). One dead adult bull trout was observed in lower Cavenaugh Creek in 2002 in the accessible reach below the falls located 0.8 kilometer (0.5 mile) upstream (Ecotrust, *in litt*. 2002). Edfro Creek is accessible to bull trout for about 0.5 kilometer (0.3 mile). A single juvenile was observed during electrofishing near the mouth of Edfro Creek in the late 1970’s (Kraemer, pers. comm. 2002). Around 1990, a bull trout approximately 380 millimeters (15 inches) in length was observed in Skookum Creek at about river mile 0.3 during the fall (Dunphy, pers. comm. 2002). In August of 2003, a subadult bull trout was observed in lower Skookum Creek, and two other subadults were observed immediately downstream of the confluence in the mainstem of the South Fork Nooksack River (Currence, pers. comm. 2003b). Potential habitat in Skookum Creek extends up to the barrier located at approximately river mile 2, and while spawning has not been confirmed, it is presumed based on water temperature profiles similar to lower Hutchinson Creek (Watershed Sciences, LLC 2002).

Hutchinson Creek is a large tributary with abundant, accessible, low gradient habitat to a 2.4-meter (8-foot) falls at about river mile 6. Pautzke (1943) reported that Hutchinson Creek supported a fair population of native char. Small juveniles have been captured in lower Hutchinson Creek below the cascades at river mile 0.8 (Maudlin *et al*. 2002). A subadult bull trout was also recorded in this reach in the 1970's (Kraemer, pers. comm. 2002). Recent snorkel surveys recorded juvenile bull trout upstream of river mile 5 (Ecotrust, *in litt*. 2002). These observations indicate migratory bull trout also spawn in upper Hutchinson Creek, as these juveniles are unlikely to ascend the cascades at river mile 0.8.

There are several low gradient tributaries in this area draining Bowman Mountain, and spawning and rearing is also presumed to occur in these systems. The tributaries downstream from Hutchinson Creek are considered unlikely to support spawning and rearing as they are smaller, have lower elevation settings more subject to thermal heating, and have relatively short accessible reaches. Snorkel surveys, minnow trapping, and screw trapping have caught bull trout in areas of the South Fork Nooksack River downstream from Hutchinson Creek, including Black Slough and a slough near river mile 12, but only smolts, foraging subadults, and adults (WDFW, *in litt*. 1994; Maudlin *et al*. 2002).

Lower Skagit core area. The Lower Skagit core area includes all of the Skagit basin downstream of Seattle City Light’s Diablo Dam (Figure 5). This encompasses all of the mainstem Skagit River downstream of Diablo Dam (including Gorge Lake), Cascade River, Sauk River, Suiattle River, White Chuck River, and Baker River (including that lake systems above Shannon and Baker Dams). Limited genetic work indicates that the native char within the lower Skagit River drainage are all bull trout while past meristic and morphological data have suggested that some may be Dolly Varden (WDFW *et al*. 1997; Spruell and Maxwell 2002). Bull trout can be found throughout these waters and their tributaries expressing various life histories and behaviors. In addition to these freshwater areas, many bull trout make extensive use of the lower estuary and near shore marine areas (*e.g.*, Skagit Bay, Port Susan) for extended rearing and subadult and adult foraging. In the lower Skagit core area, the key spawning and early rearing habitat is found in the upper portion of much of the basin. Typically this habitat is found between the 305 to 914 meter (1,000 to 3,000 feet) elevation range and often 129 kilometers (80 miles) or more upstream from the mouth of the river. Fortunately, much of this essential spawning and rearing habitat is found on Federally protected lands, either North Cascade National Park, North Cascade Recreation Area, Glacier Peak Wilderness and Henry M. Jackson Wilderness Areas.

The Lower Skagit core area supports all four life forms of bull trout: resident, fluvial, adfluvial, and anadromous. Rearing and foraging individuals may be found in nearly all anadromous reaches of the basin as well as several isolated areas above the typical anadromous zone. Bull trout are currently known

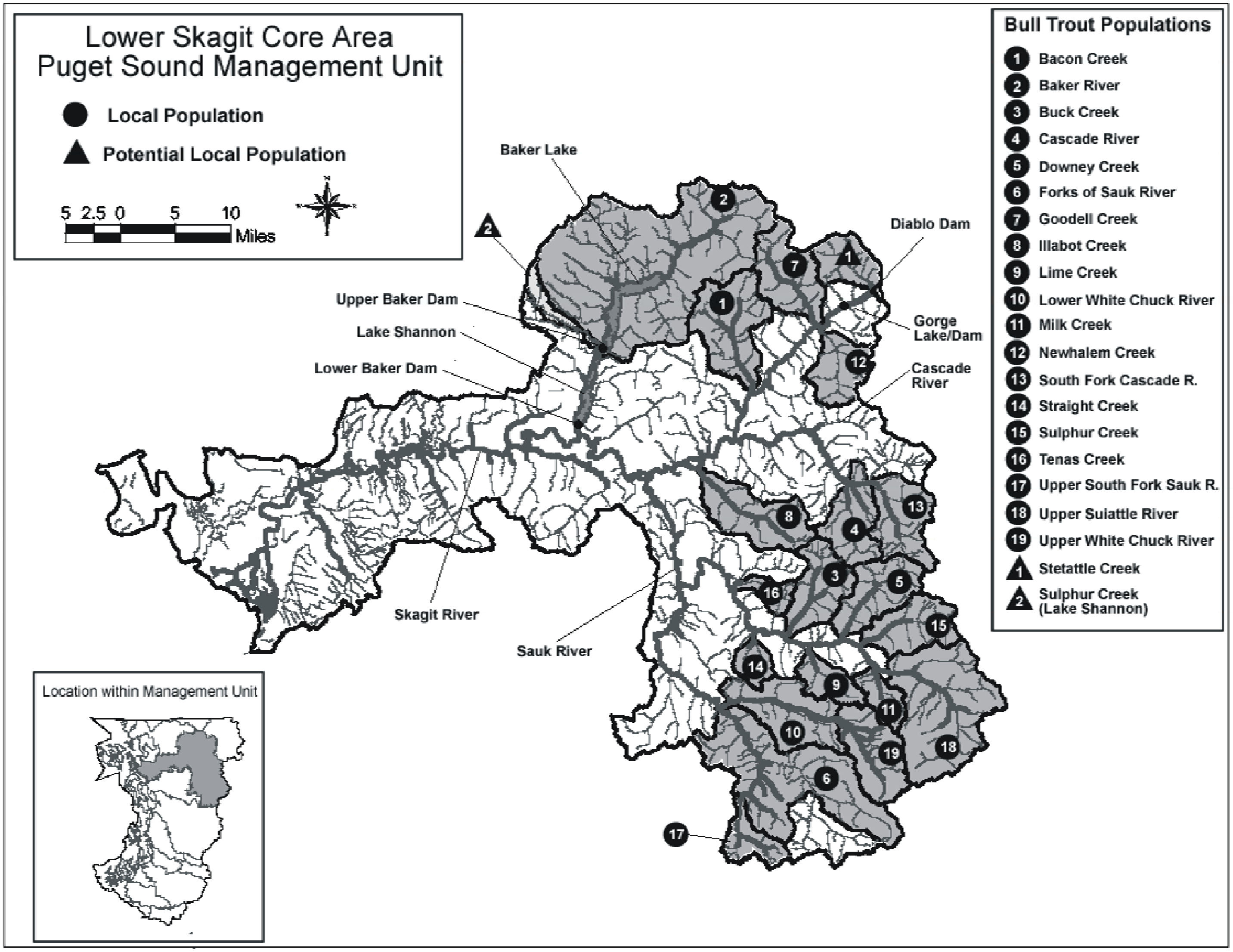

Figure 5. Lower Skagit core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

to spawn and rear in at least 19 streams or stream complexes (*i.e.*, local populations). These local populations include Upper South Fork Sauk River, Forks of Sauk River, Lower White Chuck River, Upper White Chuck River, Tenas Creek, Buck Creek, Downey Creek, Sulphur Creek (Suiattle River), Straight Creek, Lime Creek, Milk Creek, Upper Suiattle River, Illabot Creek, South Fork Cascade River, Cascade River, Bacon Creek, Goodell Creek, Newhalem Creek, and Baker Lake. The resident life history form is found in a number of these areas as well as a number of additional small tributaries. These resident life history forms often coexist with migratory life history forms within the same local populations (Kraemer, *in litt*. 2003). Adfluvial fish are found only in the Baker Lake local population. Historically, the Baker River system likely supported both fluvial and anadromous bull trout. Prior to dam construction, bull trout were reported migrating in "great quantities" up from the Skagit River into Baker Lake (U.S. Fish Commission 1901). The two hydroelectric dams, Lower and Upper Baker Dams, have greatly limited fish movement in the Baker River system, and have generally excluded the anadromous life history form from this system. A large reservoir and regulated natural lake have been created by the lower and upper dams, Lake Shannon and Baker Lake, respectively. Upper Baker River, Bald Eagle Creek, Pass Creek, Crystal Creek, Sulfide Creek, and Swift Creek are the known spawning and/or rearing areas for the Baker Lake system, while Baker Lake provides the primary habitat for foraging and overwintering. Small numbers of bull trout are collected at the adult trap and haul[†] facility at the Lower Baker Dam and transported above the dams to Baker Lake each year. Bull trout smolts have been captured at an outmigrant trap on the Baker River located below the dams, however it has not been determined whether these are smolts originating from the Baker River system or from other parts of the Lower Skagit core area (WDFW 1998). Lake Shannon, formed by the lower Baker Dam, also contains bull trout with one potential spawning tributary, Sulphur Creek. Sulphur Creek is currently identified only as a potential local population given limited information. With the collection of additional bull trout use information, Sulphur Creek may be identified as a local population in the future.

It is thought that the Lower Skagit core area supports a spawning population of migratory bull trout that numbers in the thousands, likely making it the largest population in Washington (Kraemer, *in litt*. 2001a). The resident form may be nearly as abundant. It is believed that the diverse and connected habitats found in this core area have allowed for the continued expression of the diverse life forms and behaviors that would have been typically found in robust coastal bull trout populations. Connectivity among most local populations and foraging areas is good to excellent, although some habitat diversity has been lost in the mainstem Skagit River due to channel simplification, impassable culverts, and diking and leveeing of the mainstem and estuary areas. For much of the basin, the migration corridors connecting the spawning and early rearing areas to essential downstream foraging and overwintering areas remain intact. The exceptions are the reach of the Baker River modified by the Baker River Hydroelectric Project (described previously), and the reach modified by the City of Seattle's Skagit Hydroelectric Project in the upper section of this system. The City of Seattle hydroelectric facilities on the upper river include three major dams: Gorge, Diablo, and Ross. Historical accounts by early settlers to the upper Skagit River indicate that native char and rainbow trout were present in a 13.7-kilometer (8.5-mile) reach of the river located between the present location of Gorge Powerhouse at river mile 96.5 and Ross Dam at river mile 105 (Envirosphere 1988). This reach, which is located in a steep narrow canyon, contains numerous boulder cascades, bedrock falls, and velocity barriers. Historical records indicate that salmon were not able to migrate upstream through this reach, but steelhead trout were able to migrate as far upstream as Stetattle Creek, located upstream from Gorge Dam at river mile 100. A steep and narrow bedrock gorge located at the current location of Diablo Dam probably blocked upstream migration of all migratory fish, including bull trout. Thus it may have been that genetic exchange between the upper river populations and the lower river were primarily one-way (downstream). It is possible that on rare occasions fish may have gained access beyond the barriers to the upper watershed, but it is not known for certain and likely occurred only during low flow conditions. A genetic comparison of bull trout located upstream and downstream of the project will be conducted by Seattle City Light in 2003. Currently, bull trout in the Lower Skagit core area can migrate upstream only as far as Gorge Dam.

The fluvial population within the Lower Skagit core area typically forages and overwinters in the larger pools of the upper portion of the mainstem Skagit River and to a lesser degree the Sauk River (WDFW *et al*. 1997; Kraemer, *in litt*.

2003). Expression of this fluvial life history appears to be highly dependent upon availability of forage. The abundance of Pacific salmon (especially pink [*O. gorbuscha*] and chum salmon) appears to be key in supporting this life history form. In the fall of the year, fluvial bull trout gain considerable weight by feeding on the abundance of loose eggs from the large numbers of spawning salmon. In the spring, they forage heavily on the emerging fry and outmigrating smolts. Whitefish, sculpins and other fishes are important forage species for bull trout that are available throughout the year. The sockeye salmon and kokanee population within the Baker Lake complex supplies the forage base for the adfluvial population.

A significant portion of the migratory fish in the basin exhibit an anadromous life history and use the estuarine and nearshore marine areas in Skagit Bay and Port Susan with juvenile fish as small as 135 millimeters (5.3 inches) (Kraemer 1994; Yates 2001). The anadromous fish are typically found in nearshore marine waters from the early spring through the late fall. The maintenance of marine nearshore and estuary habitat is key to supporting this life history form. The anadromous fish forage primarily on salmon smolts and marine forage fish (*i.e.*, surf smelt, sandlance, and herring) while in the estuary and nearshore marine waters (see marine foraging, migration, and overwintering habitat). Surf smelt, sandlance, and herring become more and more important as forage as the summer growing season progresses. Protecting the spawning beaches for these forage fish in Skagit Bay and Port Susan are key to maintaining the current abundance of the anadromous life history form. While the anadromous fish are in the river, either as post-spawn adults or overwintering subadults, they rely on much the same forage base as the fluvial fish (Kraemer 1994).

The population status of bull trout in the Lower Skagit core area has been tracked in recent years using indices of abundance obtained at two locations. One is a spawning index area and the other is the smolt trap on the lower Skagit River located at river mile 14. The spawning index area is on the South Fork Sauk approximately 5.6 kilometers (3.5 miles) downstream of the old town site of Monte Cristo. The index area has been surveyed annually for spawner abundance beginning in 1988 (Table 2) (WDFW 1998; M. Downen, Washington Department

Table 2. Bull trout redd counts in the South Fork Sauk River spawning index area, and bull trout smolt counts at the lower Skagit River trap (representing entire core area), 1988 to 2002 (WDFW 1998; Downen, pers. comm. 2003a).

Year	Number of redds	Smolts captured
1988	16	--
1989	7	--
1990	4	130
1991	55	112
1992	46	132
1993	54	150
1994	34	452
1995	--	368
1996	56	244
1997	--	142
1998	--	359
1999	--	199
2000	--	247
2001	167	145
2002	221	--

of Fish and Wildlife, pers. comm. 2003a). The smolt traps have been in operation since 1990 (scoop trap prior to 1993, scoop and screw trap after 1993) monitoring out-migration of juvenile salmonids (Seiler *et al*. 2002). These traps are typically operated from the first of February through the end of September. Juvenile bull trout are typically captured throughout the trap period with peak captures in May and June. Recent work on adult bull trout found that nearly all the migratory (fluvial and anadromous) bull trout found in the Lower Skagit core area mature at age four with only the occasional fish maturing at age three or five. The size of first time fluvial spawners is typically 350 millimeters (13.8 inches), while the anadromous forms begin to spawn at about 425 to 450 millimeters (16.7

to 17.7 inches) in size. Multiple spawning adults are common in the population with half or more of the spawning population being repeat spawners. Repeat spawners as old as 8 (fluvial) and 10 (anadromous) years of age have been found. Once the fish reach sexual maturity, the fish spawn annually with no evidence of alternate year (skip) spawning. Based on growth patterns on scales, it appears that at least some fish within the Lower Skagit core area may on occasion change life histories. That is, following maturation, fish of one life history may adopt another life history or foraging strategy (*e.g.*, changing from anadromous to fluvial, resident to fluvial) (Kraemer, *in litt*. 2003).

The Upper South Fork Sauk River local population includes the South Fork upstream from Monte Cristo Lake located at river mile 4.5 and its tributaries Weeden Creek, Glacier Creek, and Seventysix Gulch. This area is thought to support fewer than 500 migratory adults, as well as numerous resident fish. Tagging data and scale analysis indicates that the migratory fish are both fluvial and anadromous (Kraemer 1994; Kraemer, *in litt*. 2003). The resident component of this local population is believed to be abundant and stable (likely near historical numbers), and the migratory component appears abundant and is increasing (Kraemer, *in litt*. 2001a). Spawning and early rearing habitat is believed to be in near pristine condition.

The Forks of the Sauk River local population includes the North Fork Sauk River downstream of the anadromous barrier at river mile 41 and the South Fork Sauk River downstream of Elliott Creek. In addition to these mainstem spawning areas, bull trout spawn and rear in several small tributary streams (Elliott, Chocwich, Bedal, Merry Brook and Martin Creeks) (WDFW *et al*. 1997; Kraemer *in litt*. 2001a). Typically fewer than 100 migratory adults use this area as well as a limited number of resident fish (Kraemer, *in litt*. 2001a). Status of the resident component of this local population is unknown, and the migratory component appears abundant and is increasing based on spawning ground counts (Kraemer, *in litt*. 2003).

The Lower White Chuck River local population includes the White Chuck River and several tributaries downstream of river mile 11. Spawning and rearing appears to be limited to the major tributaries, which include Pugh, Camp, and

Owl Creeks (WDFW 2002). This local population is thought to contain fewer than 500 migratory adults as well as resident adults (Kraemer, *in litt*. 2001a). Camp Creek is located in a Wilderness area and supports a number of resident bull trout above river mile 1.0. These are generally not fished. The status of the resident component is believed to be abundant and likely stable (near historical numbers), and the migratory component appears abundant and is increasing based on available spawning information in other parts of the basin.

The Upper White Chuck River local population includes the White Chuck River and tributaries upstream of river mile 12. Spawning is believed to occur in nearly all the mainstem reaches as well as the lower reaches of many of the tributary streams in this reach. Spawning bull trout have been observed in both the mainstem as well as in Fire, Pumice, Fourteen Mile, and Glacier Creeks (WDFW 2002). The population is known to contain both migratory and resident bull trout, though the total magnitude of the population is unknown. Glacial run-off limits the ability to monitor this system effectively, however it is believed to support one of the larger local populations in the Lower Skagit core area based on the available habitat. The resident component is believed to be abundant and stable (near historical numbers) since they are located in the Glacier Peak Wilderness. The migratory component appears abundant and is believed to be increasing based on available spawning information from other parts of the Skagit basin.

The Suiattle River system has documented spawning and rearing bull trout populations in seven tributaries: Tenas, Buck, Downey, Sulphur, Straight, Lime, and Milk Creeks (WDFW 2002). Spawning and rearing has also been documented in the upper mainstem above river mile 30 and in the tributaries associated with this reach. Both migratory (fluvial and anadromous) and resident bull trout are found throughout the Suiattle River system. Although a number of resident adult bull trout have been observed throughout this system, adequate data is generally unavailable at this time to estimate their abundance within each of the local populations.

Although Tenas Creek is used by migratory bull trout for spawning and rearing, no resident bull trout have been observed in this stream. The total population is thought to be fewer than 100 adults (Kraemer, *in litt*. 2001a). The presence of spawning Chinook and pink salmon limits the opportunities to monitor this local population due to the superimposition of redds, especially in the lower reach. This local population is believed to be increasing in abundance.

Buck Creek is known to support both migratory and resident bull trout. Spawning and rearing in this subbasin is believed to extend upstream as far as river mile 6.0 and into its accessible tributary, Horse Creek. The Buck Creek local population is thought to currently contain fewer than 500 migratory adult bull trout based on the available habitat (Kraemer, *in litt*. 2001a). The resident component of this local population is believed to be abundant and stable (near historical numbers) since the majority of habitat lies within the Glacier Peak Wilderness. The migratory component is believed to be abundant and increasing.

Downey Creek is known to support both migratory and resident bull trout. Spawning and early rearing habitat for this local population is considered nearly pristine since the majority lies within the Glacier Peak Wilderness. Bull trout use in this basin extends upstream as far as river mile 6.2, and likely into its accessible tributary Goat Creek. This population is currently thought to contain fewer than 500 migratory adults based on the available habitat (Kraemer, *in litt*. 2001a). Tagging data indicates that migratory bull trout in this local population express both fluvial and anadromous behaviors (Kraemer, *in litt*. 2002). A cascade falls located at river mile 2.2 is an upstream migrational barrier to bull trout and anadromous salmon at most flows. However, during most years at peak run-off (June and early July), a limited number of adult bull trout are able to migrate past the falls and continue upstream of this point. The resident component of this local population is believed to be abundant and stable and the migratory component is believed to be abundant and increasing.

Sulphur Creek is known to support both migratory and resident bull trout. Spawning and early rearing habitat for this local population is also considered nearly pristine since the majority lies within the Glacier Peak Wilderness. Bull trout use in this basin is believed to extend upstream as far as river mile 6.0. This population is currently thought to contain fewer than 500 migratory adult bull trout based on the available habitat (Kraemer, *in litt*. 2001a). The resident component of this local population is believed to be abundant and stable and the migratory component is believed to be abundant and increasing.

Straight Creek is known to support both migratory and resident bull trout. Bull trout spawning and rearing habitat in this basin is thought to extend upstream as far as river mile 2, and into its accessible tributary Black Creek. This population is thought to contain fewer than 100 migratory adult bull trout and an unknown number of resident adults (Kraemer, *in litt*. 2001a). The status of the resident component of this local population is unknown, however the migratory component is believed to be stable.

Lime Creek is known to support both migratory and resident bull trout. Bull trout spawning and rearing habitat in this basin is thought to extend upstream several miles. This population is thought to contain fewer than 100 migratory adult bull trout based on the presumed available habitat (Kraemer, *in litt*. 2001a). Migratory bull trout are typically confined to using the lower 0.8 kilometer (0.5 mile) of this stream below a steep cascade/falls, while resident forms can be found upstream of this point. The upper extent of this distribution is unknown. Both the resident and migratory components of this local population are believed to be abundant.

Milk Creek is known to support primarily resident bull trout, although it likely that a limited number of migratory fish regularly use the lower reach of the stream. Spawning and early rearing habitat for this local population is considered nearly pristine since it is completely within the Glacier Peak Wilderness. The resident component is believed to be abundant and stable (near historical numbers).

The upper Suiattle River local population includes the main Suiattle River upstream of river mile 30 and its associated tributaries (Dusty, Small, Miners, Vista, and Canyon Creeks). Both migratory and resident fish are found in this area with most spawning occurring in the lower reaches of the tributary streams. Spawning and early rearing habitat in this local population is currently in pristine condition. The adult abundance of all life history forms in this local population is currently unknown since only limited surveys have been conducted in this system.

Illabot Creek is a major tributary to the mainstem Skagit River and supports an abundant population of migratory and resident bull trout. Most spawning in this local population occurs upstream of river mile 8 and in Arrow Creek, with resident fish found primarily in the area near Illabot Lake. This local population is thought to contain fewer than 500 migratory adult bull trout (Kraemer, *in litt*. 2001a). Tagging data indicates that the migratory fish using this system express both fluvial and anadromous behaviors (Kraemer, *in litt*. 2002). The resident component of this local population is believed to be abundant and stable and the migratory component is believed to be abundant and increasing.

In the South Fork Cascade River bull trout have been observed as far upstream as river mile 23. Both resident and migratory fish are found in this reach, with tributary use limited to areas near the mouths of these tributary streams. Spawning and early rearing habitat in this local population is considered nearly pristine since the majority of habitat lies within the Glacier Peak Wilderness. The migratory component of this local population is thought to have fewer than 500 adults and is believed to be abundant and stable (Kraemer, *in litt*. 2001a). Although the abundance of the resident component is unknown, it is believed to be near historical numbers based on habitat conditions. The Cascade River local population consists of the mainstem reach between river mile 16 and the junction of the Cascade River forks, including the tributaries Kindy Creek and Sonny Boy Creek. Much of the spawning and rearing habitat in these two tributaries lies within Glacier Peak Wilderness. This area is thought to support a migratory population of bull trout of fewer than 100 adults (Kraemer, *in litt*. 2001a). The resident and migratory components of this population are considered stable.

In the Bacon Creek system, bull trout spawn and rear primarily in the East and West Forks of Bacon Creek with the East Fork being the most important of the two spawning areas. The total extent of use is unknown at this time, however it is believed that spawning may occur in 6.4 kilometers (4.0 miles) or more of the East Fork and only 3.2 kilometers (2.0 miles) of the West Fork. Spawning and early rearing habitat in the two forks is considered nearly pristine. Both resident and migratory fish have been observed in this population. The migratory population is thought to contain fewer than 500 adults (Kraemer, *in litt*. 2001a).

In Goodell Creek, bull trout spawning and rearing is confined to primarily the mainstem reaches. The upper limit of bull trout spawning and rearing is currently unknown, but may extend as far upstream as river mile 6.0. Spawning and early rearing habitat lie primarily in the North Cascades National Park. Both resident and migratory bull trout are found in this population. The migratory form is thought to currently number fewer than 500 adults, but is believed to be increasing (Kraemer, *in litt*. 2001a). The resident component of this local population is believed to be near historical numbers because of intact habitat conditions.

Prespawning adult bull trout have been reported staging in the lower reaches of Newhalem Creek, however the success of any spawning in the lower reaches is unknown (Kraemer, pers. comm. 2003b). The total adult abundance of this local population is currently unknown since no monitoring has occurred in this system.

The Baker Lake system contains the only adfluvial population in this core area. Bull trout are present in both Baker Lake and Lake Shannon. Spawning and rearing is known to occur in the Baker River above Baker Lake, as well as in Bald Eagle Creek, a tributary to the upper Baker River. Baker Lake is the primary foraging and overwintering habitat for subadult and adult life stages of the adfluvial form in the Baker Lake local population, however the Baker River likely also provides foraging and overwintering habitat. In 1986, 23 adult bull trout were observed staging in the Baker River within 0.8 kilometer (0.5 mile) of Bald Eagle Creek (WDFW *et al*. 1997). In the following year, 32 adult bull trout were observed actively spawning within 0.4 kilometer (0.25 mile) of the confluence. In 2001, adult bull trout were observed in Bald Eagle Creek at river mile 0.9 in the pool at the base of the migratory barrier (R2 Resource Consultants 2003). Adult and juvenile bull trout have also been observed within the Baker River tributaries, Sulphide, Crystal, and Pass Creeks (Glesne, *in litt*. 1993; R2 Resource Consultants 2003), and in the Baker Lake tributary, Swift Creek (Zyskowski, pers. comm. 2003d). Three adult and one subadult bull trout were recently observed in the Baker Lake tributary, Park Creek, during November 2003 surveys (Greenberg and Appy, *in litt*. 2003; M. Appy, R2 Resource Consultants, pers. comm. 2004). It is unknown if the upper reaches of the Baker River may still support resident and fluvial forms of bull trout in addition to the adfluvial form. Their presence would be consistent with the apparent overlap of life history forms observed in other parts of the Lower Skagit core area. Spawning and early rearing habitat not modified by the placement of the dams is considered in nearly pristine condition, however the 9 miles of the Baker River mainstem and the lower portions of tributaries in the inundated reach between the dams no longer provide potential spawning habitat. The adult abundance in this population is currently unknown.

The bull trout observed in Lake Shannon are suspected to be fish that have dropped downstream past the Upper Baker Dam from Baker Lake and are no longer able to return upstream. Lake Shannon may currently act as a sink for those individuals that do not migrate past the Lower Baker Dam. Although Lake Shannon provides foraging and overwintering habitat, no bull trout spawning or rearing has been confirmed in any of the tributaries to the lake; however, spawning has recently been suspected in Sulphur Creek and bull trout might also be able to use Thunder Creek (Huddle, pers. comm. 2003b). In October 2002, four redds were identified in the lower reach of this system. They were believed to be bull trout redds based on their size and the time of year they were constructed (Huddle, pers. comm. 2003b). More recently, six adult sized bull trout were observed in Sulphur Creek during November 2003 surveys (Greenberg and Appy, *in litt*. 2003; Appy, pers. comm. 2004). In the early 1980's, bull trout were reported in the short (150 meter; 492 feet) accessible reach of Bear Creek (R2 Resource Consultants 2003). Although water temperatures in Bear Creek might be too warm for part of the year to support successful spawning and rearing (R2 Resource Consultants 2003), bull trout could use this system for seasonal foraging.

Currently one potential local population has been identified in the Gorge Lake system, Stetattle Creek. Bull trout in Gorge Lake are isolated from the other lower Skagit River local populations by Gorge Dam, although it is possible some one-way exchange may occur during spill events. There is a limited amount of available spawning and rearing habitat in the Gorge Lake system. Available spawning and primary rearing habitat would consist of the lower 2.7 kilometers (1.7 miles) of Stetattle Creek and potentially the lower portion of the Skagit River mainstem from the reservoir up to Diablo Dam (less than 1.6 kilometers; 1 mile) (WDFW 1998). Spawning has not yet been confirmed in Stetattle Creek, although Gorge Lake does provide the foraging and overwintering habitat for bull trout residing in this system. If spawning does not occur within Stetattle Creek, Gorge Lake may be acting as a population sink for bull trout. These fish may have entered the system from the Upper Skagit core area through spill events at Diablo Dam. The adult abundance in the Gorge Lake system is currently unknown.

Upper Skagit core area. The Upper Skagit core area includes the Skagit basin upstream of Diablo Dam, including Diablo Lake and the majority of Ross Lake (Figure 6). A significant portion of the upper Skagit River drainage lies within British Columbia, Canada, and is functionally part of this core area. The upper Skagit River is a transboundary system that flows south from British Columbia into the United States. Much of the bull trout habitat in the upper Skagit River watershed is undisturbed, since a large portion of this watershed is located within North Cascades National Park, Pasayten Wilderness, and Skagit Valley Provincial Park. The Upper Skagit core area supports populations of both bull trout and Dolly Varden (McPhail and Taylor 1995). Adfluvial, fluvial, and potentially resident life history forms of bull trout are present in the upper Skagit drainage. Adfluvial bull trout are present in Ross Lake, while fluvial forms of bull trout are found in the upper Skagit River within British Columbia. Fluvial forms may also be present in Ruby Creek, a large tributary to Ross Lake. Resident bull trout are also found in several British Columbia tributaries to the upper Skagit River including Nepopekum and Snass Creeks, and the Klesilkwa, Sumallo, and Skaist Rivers.

Prior to dam construction, some tributaries to Ross Lake were inaccessible (including Big Beaver Creek) or had limited access by migratory forms (Smith and Anderson 1921). Resident bull trout are also believed to be present in the Lightning Creek drainage (S. Zyskowski, pers. comm. 2003c), and are likely to be present in the Big Beaver Creek, Little Beaver Creek, and Ruby Creek drainages as well as smaller tributaries to Ross Lake. Dolly Varden have been found in headwater tributaries of the Skagit River in British Columbia including Nepopekum Creek (McPhail and Taylor 1995), and are likely present in

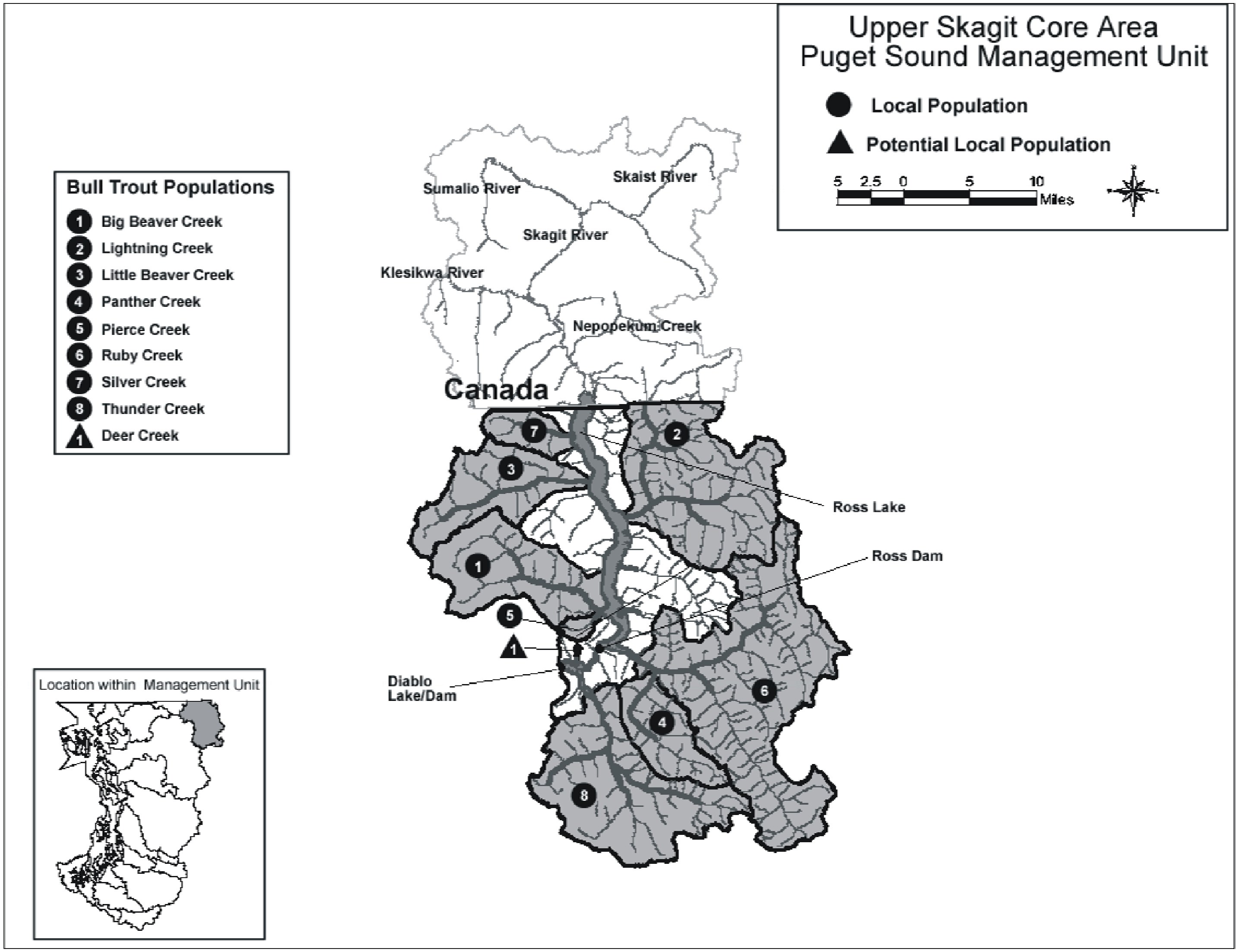

Figure 6. Upper Skagit core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

tributaries of the Skagit in the United States as well. Recent genetics analysis of several yearling individuals captured in Diablo Lake near the mouth of Thunder Creek were determined to be Dolly Varden (Spruell and Maxwell 2002). Populations of Dolly Varden in the upper Skagit River drainage appear to be spatially segregated from bull trout, with Dolly Varden typically found above those areas possessing resident and migratory bull trout. Genetics analysis of native char in the upper Skagit River drainage in British Columbia indicates that there is an unusually high level of hybridization between bull trout and Dolly Varden in this system, with over 50 percent of Dolly Varden found to possess bull trout genetic markers (McPhail and Taylor 1995). This finding indicates that the distribution of bull trout and Dolly Varden have overlapped sometime in the past and may continue to overlap in some areas. It is possible that the filling of Ross Lake provided bull trout access to previously isolated Dolly Varden populations (D. McPhail, University of British Columbia, pers. comm. 1999).

The population status of bull trout and Dolly Varden in the upper Skagit River drainage is generally unknown. In British Columbia, the status of the Skagit River stock of bull trout is categorized as “presumed healthy” (*i.e.*, viable for at least 20 years if no new threats are added to watershed and data are available for populations in the watershed, or absence of significant threats and there was a known occurrence of bull trout in watershed) (BCMWLAP 2002). Bull trout are known to spawn and rear in at least eight streams (*i.e.*, local populations) in the United States; these are Ruby Creek (including Canyon and Granite Creeks), Panther, Lightning, Big Beaver, Little Beaver, Silver, Pierce, and Thunder Creeks (WDFW 1998; Ed Connor, Seattle City Light, pers. comm. 2003a). Recent spawning surveys indicate the majority of bull trout in the Upper Skagit River core area spawn in the mainstem Skagit River and in a number of its tributaries within British Columbia. Bull trout spawn and rear in at least six streams in the Skagit River drainage north of the United States-Canada border, including the mainstem Skagit, upper (East Fork) Skagit, Klesilkwa, Skaist, and Sumallo Rivers, and Nepopekum Creek (McPhail and Taylor 1995). Bull trout spawning and rearing may also occur in McNaught, St. Alice Creek, Maselpanik, and Snass Creeks (McPhail and Taylor 1995). No spawning index areas have been established in this drainage within either Washington or British Columbia, so only rough estimates of abundance are available for a few local populations.

Adfluvial bull trout have been observed staging and migrating into many of these tributaries of Ross Lake to spawn, including Ruby Creek, Lightning Creek, Big Beaver Creek, Little Beaver Creek, and Silver Creek. The largest runs of adfluvial fish south of the United States-Canada border are in Lightning Creek and Ruby Creek (Hopkins, *in litt*. 2002; Connor, in *litt*. 2003). Up to several dozen fish at a time can be observed staging at the mouths of these tributaries from mid-September through mid-November. Relatively large numbers of adfluvial bull trout (more than 100) can be observed holding in the upper Skagit River just north of the border by the end of September. These staging adults are known to spawn in the upper Skagit River and tributaries including the Sumallo River, Klesilkwa River, and Nepopekum Creek.

Although large juvenile or subadult bull trout (150 to 200 millimeters; 5.9 to 7.8 inches) have been observed at the mouth of Devil Creek, this system is similar to Little Beaver Creek in that it is located in an extremely steep and narrow canyon (Connor, pers. comm. 2003a). The lower 0.8 kilometer (0.5 mile) of this stream is also inundated by Ross Lake when it is near full pool elevation. However, this stream is dominated by large boulders and bedrock, so upstream migration beyond the lake inundation zone is unlikely due to numerous boulder and bedrock cascades and waterfalls in this stream. Areas surveyed upstream of these barriers were found to be inhabited only by cutthroat trout. Roland Creek supports a significant spawning run of adfluvial rainbow trout, however spawning use by bull trout has not been determined (Connor, pers. comm. 2003b). Roland Creek is likely an important foraging area for bull trout due to its productivity. A single subadult bull trout was observed in 2002 during rainbow trout broodstock collection efforts (Connor, pers. comm. 2003d).

Ruby Creek is the largest tributary entering Ross Lake within the United States. Ruby Creek has a relatively low gradient where it enters Ross Lake, providing good access for bull trout migrating into this stream from the lake. Early biological surveys conducted prior to the construction of the three Seattle City Light dams reported that native char were abundant in Ruby Creek, with these fish reaching 3.6 to 4.5 kilograms (8.0 to 10.0 pounds) in weight (Smith and Anderson 1921). U.S. Forest Service and Seattle City Light biologists have observed bull trout spawning within the lower 3.2-kilometer (2-mile) section of

Ruby Creek. The two major tributaries in this system are Canyon and Granite Creeks. Canyon Creek is believed to provide spawning and rearing habitat for this system based on recent habitat surveys (Hopkins, *in litt*. 2002). Pre-spawning bull trout appear to arrive in mid-August and hold in cold groundwater-fed pools in the upper reach of Canyon Creek above the confluence with Slate Creek (D. Hopkins, U.S. Forest Service, pers. comm. 2002). Granite Creek also supports some bull trout use, however current habitat conditions are believed to be limiting for spawning and rearing. Based upon snorkeling and electrofishing surveys conducted by the U.S. Forest Service, bull trout do not appear to use more than a few miles of lower Granite Creek (J. Molesworth, U.S. Forest Service, pers. comm. 2002). Although in the past bull trout were captured in the Ruby Creek tributary, Crater Creek (Glesne, *in litt*. 1993), it is not known whether this is still part of their current distribution within the system. Panther Creek is a tributary to the lower reach of Ruby Creek. The lower section of Panther Creek is steep and it is currently unknown if migratory bull trout are able to use this tributary. Bull trout in this stream appear to be primarily the resident form (Connor, pers. comm. 2003a). The upper limit to the distribution of bull trout in this stream is currently unknown.

Big Beaver Creek is the second largest tributary to Ross Lake. Spawning and rearing habitat for bull trout is believed to occur primarily in the upper reaches of Big Beaver Creek based on habitat surveys. Snorkeling surveys suggest that juvenile rearing in the lower reaches of Big Beaver Creek is mainly limited to a large complex of beaver ponds situated along this stream. Spawning and rearing surveys have not yet been conducted in the upper Big Beaver Creek drainage. However, the best spawning and rearing habitat for bull trout may be located in upper reaches of this stream (Johnston, pers. comm. 1999b). The distribution within Big Beaver Creek is thought to extend to about the confluence of Luna Creek. Spawning and rearing is also presumed to occur in its accessible tributary, McMillan Creek.

Little Beaver Creek is located in an extremely steep and narrow canyon. The lower 0.8 kilometer (0.5 mile) reach of Little Beaver Creek is annually inundated by Ross Lake when it is near full pool, which usually occurs between mid-July through mid-November. Upstream passage by migrating bull trout may be difficult due to numerous boulder and bedrock cascades and waterfalls within this system.

Lightning Creek probably has the best habitat conditions for bull trout of all the Ross Lake tributaries. Like Little Beaver Creek and Devil Creek, the lower end of this stream is located in a steep and narrow canyon section which is inundated by the reservoir when it is near full pool. Lightning Creek is less confined by bedrock and lower in gradient than Little Beaver and Devil Creek upstream of Ross Lake, and consequently provided much better upstream passage conditions for migrating fish. Spawning bull trout have been observed in the lowest 3 kilometers (2 miles) of Lightning Creek, however, since spawning surveys have not been conducted above this section, the complete distribution is unknown. Given the near pristine habitat conditions, bull trout are presumed to use all the accessible reaches and tributaries in this system, including upper Three Fools Creek, Cinnamon Creek, and Freezeout Creek. High densities of juvenile and resident bull trout have been observed in the upper reaches of Lightning Creek, including lower Three Fools Creek, during snorkeling surveys conducted by the National Park Service and U.S. Forest Service (Hopkins, pers. comm. 2002).

Silver Creek is a moderate gradient stream, which currently appears to have a highly unstable channel and banks. These channel characteristics suggest that a recent mass wasting event or other type of natural watershed disturbance has occurred in the upper watershed of this stream. Both bull trout and brook trout have been documented spawning in this system (Connor, *in litt*. 2003).

Hozemeen Creek is located immediately south of the United States-Canada border, and is believed to support few bull trout due to relatively poor habitat conditions caused by high sediment loads, debris barriers, and warm water temperatures originating from historical logging in the upper watershed and the presence of nonnative brook trout (Connor, *in litt*. 2003).

Although no spawning has been observed in Pierce Creek, young-of-year bull trout were observed in this system during snorkel surveys conducted in the fall of 1999 (Connor, pers. comm. 2003a). Adfluvial bull trout kelts (surviving post-spawning adults) were also observed at the mouth of Pierce Creek during this same survey period. A 24.4-meter (80-foot) waterfall located approximately 0.8 kilometer (0.5 mile) upstream from the mouth of this stream is a total barrier to the upstream migration of adfluvial fish.

Ross Lake is a 38.6-kilometer (24-mile) long reservoir impounded by Ross Dam, which is operated by Seattle City Light. This reservoir provides foraging, migration, and overwintering habitat for the adfluvial bull trout that spawn and rear in tributaries to Ross Lake, the upper Skagit River in Canada, and tributaries to the upper Skagit River. Large numbers of juvenile bull trout typically greater than 200 millimeters (7.9 inches) have been observed to congregate in Ross Lake at the mouth of Big Beaver Creek, Devil Creek, and in Ruby Creek, Lightning Creek, and the upper Skagit River immediately above the reservoir (Connor, *in litt*. 2003). These areas likely provide important foraging for larger juvenile bull trout, which feed on small rainbow trout, as well as provide coldwater refuge for juvenile and adult bull trout. The upper Skagit River also provides important bull trout foraging habitat for this core area, with the main prey reported to be Dolly Varden and rainbow trout (McPhail and Taylor 1995). Ross Dam is currently a passage barrier to the upstream and downstream migration of bull trout and Dolly Varden between Ross Lake and Diablo Lake. Bull trout may move downstream during periods of spill at Ross Dam, though spill events at this dam are rare. Studies are presently being initiated to determine whether there are genetic differences between populations of bull trout and Dolly Varden in Ross Lake and Diablo Lake.

Immediately downstream of Ross Dam is Diablo Lake, a 6.4-kilometer (4.0-mile) long reservoir with a limited number of spawning and rearing tributaries. This reservoir, formed after the construction of the Diablo Dam, provides foraging, migration, and overwintering habitat for bull trout and Dolly Varden. Prior to the construction of Diablo Dam, this section of the Skagit River flowed into Thunder Lake. Biological surveys conducted by University of Washington researchers prior to the construction of Diablo Dam reported that trout transplanted[†] from the Lake Chelan system were present in Thunder Lake, presumably rainbow or cutthroat trout (Smith and Anderson 1921). Thunder Creek is the largest tributary to Diablo Lake, and is believed to provide the primary spawning and rearing habitat today. Spawning conditions are considered to be excellent in this stream due to abundant gravels situated within long runs and glides having depths and velocities which were well suited for spawning by bull trout, however flows are extremely "flashy" in this stream due to glacial runoff (Glesne, pers. comm. 2003). Egg and fry survival may be low in the mainstem sections of Thunder Creek due to the extreme variability of flows in this stream and scour[†] by fine sediments mobilized during these events. Spawning and early juvenile rearing are more likely to be successful in "clear running" tributaries to Thunder Creek (P. Castle, Washington Department of Fish and Wildlife, pers. comm. 2003a). Juvenile char have been observed in the lower reaches of Thunder Creek (Craig, *in litt*. 2000a; Zyskowski, pers. comm. 2002b). Very limited genetic sampling of juvenile char in the Diablo system has identified only Dolly Varden, however, bull trout are also likely present. Large native char are frequently captured by anglers in this lake, strongly suggesting that bull trout are also present in this system (Downen, pers. comm. 2002; Zyskowski, pers. comm. 2003a). There are two additional tributaries to the Diablo Lake system where bull trout or Dolly Varden were observed in the past. In 1976, spawning bull trout or Dolly Varden were documented in Deer Creek, which is located near the Diablo Lake Resort (Glesne, *in litt*. 1993). This is a small creek system with limited habitat. It has not been determined whether spawning and rearing may still occur here. During this same time period, bull trout or Dolly Varden were also observed in the lower reaches of Colonial Creek, a tributary to the Thunder Arm of Diablo Lake (Glesne, *in litt*. 1993).

Stillaguamish core area. The Stillaguamish River basin, including both the North and South Forks, comprises the Stillaguamish core area (Figure 7). Major tributaries to the North Fork include the Boulder River, Deer Creek, and its tributary, Higgins Creek. Canyon Creek constitutes the only major tributary to the South Fork, which also receives water from several minor tributaries including Palmer, Perry, and Beaver Creeks. Spawning habitat is believed to be somewhat limited, where in most cases only the extreme upper reaches of these waters appear to provide adequate spawning conditions. This is believed to have been the case historically due to the lack of accessible high elevation stream habitat and instability of soils found in the basin, but has been further reduced from the effects of land management activities. In some cases, access to these

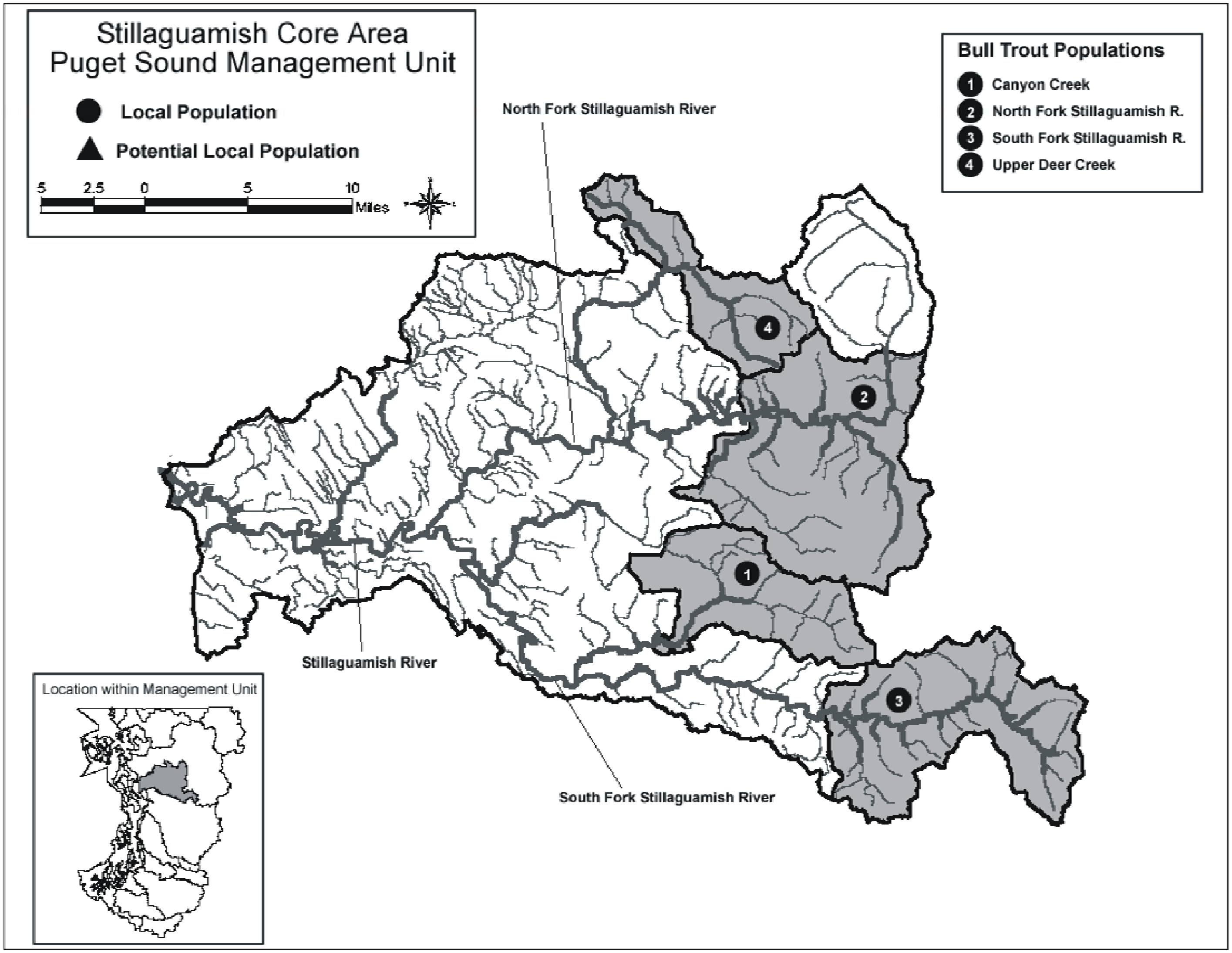

Figure 7. Stillaguamish core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

reaches are blocked by natural barriers. Rearing and foraging habitat does exist downstream of these areas. For example, large juvenile or subadult bull trout have been observed or captured in Big Four Creek (K. Nelson, Tulalip Tribe, pers. comm. 2003; Chang, *in litt*. 2003), a short tributary to the South Fork Stillaguamish River which enters just downstream of Perry Creek. This core area is believed to support primarily anadromous and fluvial life history forms. No exclusively resident populations have been identified in this core area, but the South Fork population does have a strong resident component which coexists with migratory forms.

The paucity and spatial isolation of available spawning habitat suggest that only four local populations likely exist in the Stillaguamish core area: Upper Deer Creek (including Higgins Creek); the North Fork Stillaguamish River (including a major tributary, the Boulder River, and potentially Squire Creek); the South Fork Stillaguamish River (including its upper minor tributaries); and Canyon Creek (major tributary to the South Fork Stillaguamish River). These local populations are somewhat isolated from one another, therefore maintaining connectivity between each of these within the core area will be critical.

In the Upper Deer Creek local population, bull trout have been observed spawning in Higgins Creek and are suspected in upper Little Deer Creek as well. Juvenile bull trout sampled in low numbers during U.S. Forest Service stream surveys in Higgins Creek provide further evidence for successful reproduction. In October 1983, two pairs of adult bull trout and eight redds were incidentally observed between river mile 1.0 and 1.5 during stream surveys (Doyle, pers. comm. 2003). No resident populations have been found above any of the natural migratory barriers on Deer or Higgins Creeks. Spawning and early rearing habitat in this local population is currently believed to be in poor condition resulting from past forest management (Deer and Higgins Creeks currently violate State water quality standards for temperature), but is believed to be recovering. Current population abundance is believed to be low.

In the North Fork Stillaguamish River local population, upwards of 100 adult bull trout have been observed holding in the mainstem of the North Fork Stillaguamish River below the mouth of the Boulder River. Fall snorkel surveys conducted between 1996 and 2003 counted close to 300 adult char in the reach between river mile 21 and 25 during fall 2001, although counts were fewer than 100 adults for the remaining sample years (Pess, *in litt*. 2003). Other limited snorkel survey efforts have made similar observations (Downen, pers. comm. 2003b). Due to limited information on spawning distribution within this part of the system and the presence of other fall-spawning species, adult counts of staging bull trout appear to be the best monitoring tool for this local population. These staging adult bull trout are assumed to spawn somewhere in the North Fork. Bull trout have been observed spawning in the extreme accessible portion of the upper North Fork and in the Boulder River below the impassible falls at river mile 3. Currently no extensive juvenile sampling or evaluation of spawning success has occurred in the North Fork. There are no known populations in the North Fork above the anadromous barrier at river mile 37.5 (Kraemer, *in litt*. 1999a). In addition, no resident populations have been identified above the barrier on the Boulder River. Spawning and early rearing habitat is limited primarily due to natural barriers on the Boulder River and lack of headwater habitat with suitably cold water temperatures. Warmer water temperatures in the summer may also limit movement of juvenile bull trout. Current population abundance in the Boulder River is believed to be low, fewer than 100 adults. While unconfirmed, spawning and rearing is also suspected in the Squire Creek system, which is similar in size to Boulder River, and also influenced by snowmelt from Whitehorse and Three Fingers mountains. In the late 1980's, bull trout approximately 457 millimeters (18 inches) in length were observed holding in Squire Creek just downstream of the mouth of Aston Creek (Castle, pers. comm. 2003b). The natural anadromous barrier in Squire Creek is reported to be at river mile 7.9. As better distribution information is collected, Boulder River may be separated from the rest of the North Fork Stillaguamish River into its own local population.

In the South Fork Stillaguamish River, bull trout are currently known to use Palmer, Perry, and Buck Creeks and the upper South Fork mainstem above Palmer Creek for spawning and rearing. It is uncertain whether bull trout were present in the South Fork above Granite Falls prior to construction of the fishway facility in the 1950's, but anecdotal information from fish surveys in the 1920's and 1930's suggest bull trout may have existed here prior to the construction

(WDFW 1998). Recently initiated spawning surveys have identified a major spawning area above the Palmer Creek confluence. Between 50 and 100 bull trout have been observed using this reach to spawn, and electrofishing surveys conducted by Washington Department of Fish and Wildlife personnel have also documented high densities of juveniles (Downen, *in litt*. 2003). Fish believed to be resident bull trout have also been sampled in Palmer Creek. Spawning and early rearing habitat in this local population is currently believed to be in fair condition. Although fish have been observed spawning in the upper South Fork and other tributaries, available habitat is likely partially limited by gradient and competition with coho salmon. Upstream movement of bull trout from the lower river is currently dependent upon proper functioning of the fish ladder at Granite Falls. There has been no evaluation of bull trout passage past this facility. Current population abundance is believed to be low. Migratory and resident fish are both present and commingle on the spawning grounds. Conservative estimates of current population size based on spawning and electrofishing surveys suggest that between 50 and 100 adult spawners are present in this population (Downen, *in litt*. 2003).

In the Canyon Creek local population, bull trout are known to use the upper South Fork of this system for spawning and rearing. Both Washington Department of Fish and Wildlife and U.S. Forest Service staff have made isolated and incidental observations of spawning by migratory size bull trout. However, recent electrofishing surveys by the Washington Department of Fish and Wildlife have been unable to locate any juvenile or resident bull trout from this population. Spawning and early rearing habitat in this local population is currently believed to be in poor condition. Logging and the low elevation of this tributary put both natural and anthropogenic constraints on spawning and rearing habitats. Warmer summer temperatures and low water resulting from habitat problems associated with logging and mass wasting issues likely limit suitable juvenile rearing habitat. Current population abundance is believed to be low. Difficulty in locating individuals from this population despite repeated survey efforts suggests this population currently exists in very low numbers.

During some years, juvenile and subadult bull trout have been captured by smolt trapping efforts conducted in the lower Stillaguamish River. In 2002, a single bull trout was captured each month between March and June (Griffith, *in litt*. 2002). Fish captured were 50, 130, 142, and 345 millimeters (2, 5.1, 5.6, and 13.6 inches) in length, indicating that some level of juvenile rearing may take place within the mainstem.

Primary foraging, migration, and overwintering areas in this river basin include the mainstem areas of the North and South Forks, and the Stillaguamish River to the estuary. Foraging subadults and adults may be found in nearly all anadromous reaches of the basin, while rearing individuals may utilize nearly all accessible reaches in higher elevation and coldwater portions of the basin. Like anadromous populations in the Lower Skagit and Snohomish-Skykomish core areas, anadromous forms in the Stillaguamish core area are presumed to use nearshore marine areas in Skagit Bay, Port Susan, and Possession Sound.

Snohomish-Skykomish core area. The Snohomish-Skykomish core area includes the Snohomish, Skykomish and Snoqualmie Rivers and all their tributaries (Figure 8). Bull trout can be found throughout these waters, generally downstream of anadromous barriers. They are not known to be present upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, upstream of the lower reaches of the forks of the Tolt River, upstream of Deer Falls on the North Fork Skykomish River, or upstream of Alpine Falls on the Tye River (Kraemer, *in litt*. 1999b). Fluvial, resident and anadromous life histories are all found within the basin. There are no lake systems within the basin that support typical adfluvial populations, however anadromous and fluvial forms occasionally forage in a number of lowland lakes having connectivity to the mainstem rivers. A large portion of the migratory segment of this population is anadromous, and these forms make extensive use of the lower estuary and nearshore marine areas for extended rearing.

Rearing bull trout can be found throughout the anadromous portions of the Snohomish, Skykomish, North Skykomish and South Fork Skykomish with occasional use in the other portions of the anadromous reaches of the basin. A population containing only resident forms is found in Troublesome Creek on the North Fork Skykomish River. This resident bull trout population is upstream of a migration barrier at river mile 0.5. Infrequent access to Troublesome Creek

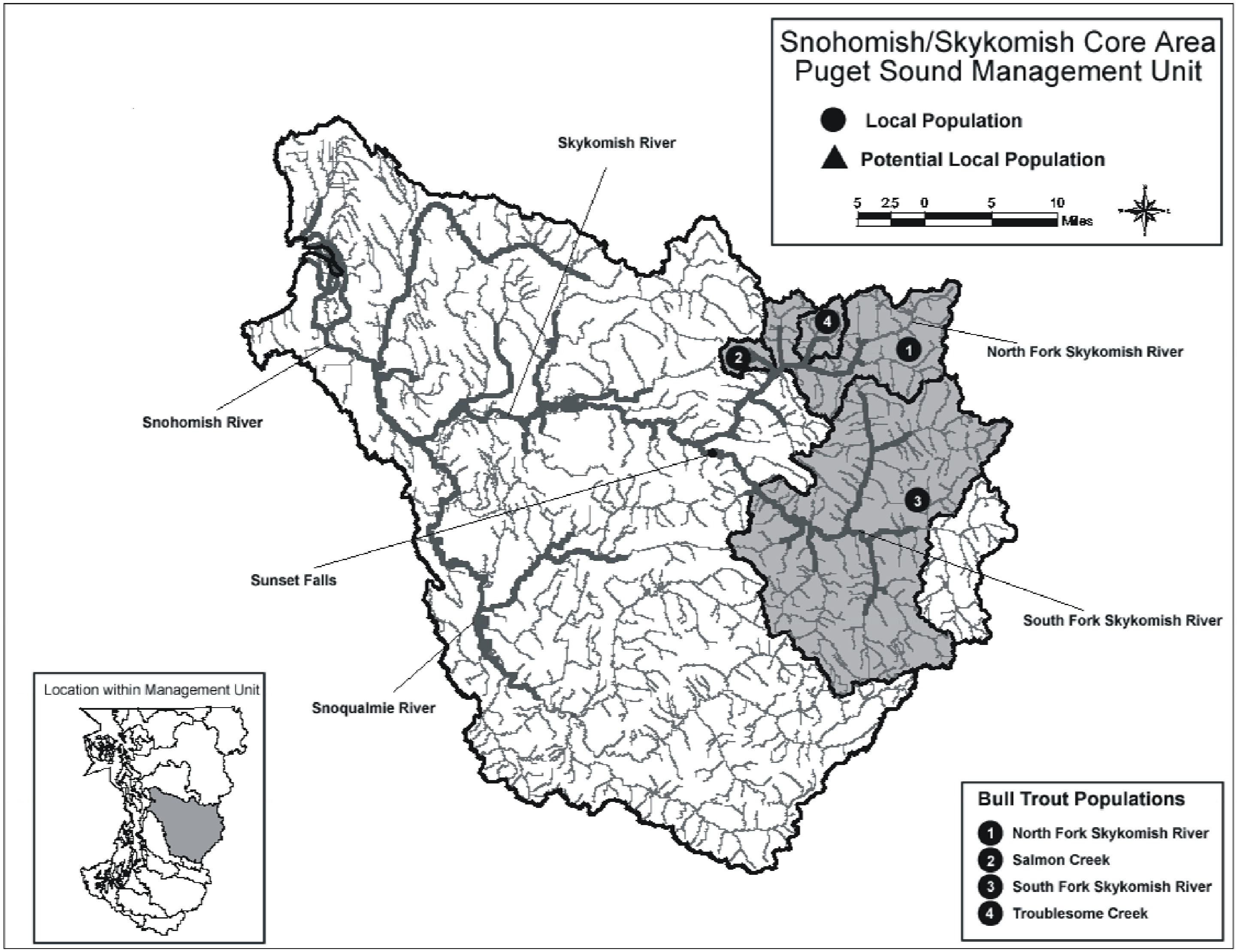

Figure 8. Snohomish/Skykomish core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

above the barrier by summer steelhead has been documented at least once in the last 15 years (Kraemer, pers. comm. 2003b). It is possible that migratory bull trout may occasionally migrate to the upper basin under the same conditions that allow steelhead access upstream of this barrier. The known spawning and early rearing areas of the Skykomish River basin are all found at an elevation of 305 to 457 meters (1,000 to 1,500 feet). Because of the topography of the basin, the amount of key spawning and early rearing habitat available is more limited than in some basins. Primary spawning and early rearing habitat for bull trout is found in the upper North Fork Skykomish River drainage. The major areas of production include the North Fork Skykomish River between Bear Creek Falls and Deer Falls, Goblin Creek, Troublesome Creek, and Salmon Creek. In addition, in the last several decades a migratory bull trout population has become established in the East Fork Foss and Beckler Rivers on the South Fork Skykomish River. This group of fish gained access to the area upstream of the historical anadromous barrier in 1958 when the Washington Department of Fish and Wildlife (then the Department of Fisheries) instituted a trap and haul operation to move fish over Sunset Falls (Kraemer, *in litt*. 1999b). Currently four local populations have been defined for this core area: North Fork Skykomish River (includes Goblin Creek and West Cady Creek); Troublesome Creek; Salmon Creek; and South Fork Skykomish River. Information gathered through ongoing and future bull trout research within the basin may result in the need to reevaluate these local populations.

Bull trout spawn in the North Fork Skykomish River local population upstream of Bear Creek Falls to Deer Falls, as well as in Goblin Creek and West Cady Creek. This area supports as many as 500 migratory adults based on redd counts as well as a small number of resident fish (only occasionally observed). The migratory fish are thought to be primarily the anadromous life history form. Recent genetic work (DNA) indicates that these fish are all bull trout, while prior meristic and morphological data has indicated that some may be Dolly Varden (WDFW 1998; Kraemer 1994). Spawning and early rearing habitat is generally in good condition. The abundance of the resident component of this local population is currently unknown.

The Troublesome Creek local population is primarily a resident population with typically only resident fish found upstream of the natural barrier located approximately 0.4 kilometer (0.25 mile) upstream from the mouth. The abundance of the resident population is currently unknown, but is believed to be stable due to intact habitat conditions. Spawning and early rearing habitat is believed to be in good to excellent condition given the upper reaches of this system are within the Henry M. Jackson Wilderness. A few migratory fish are seen annually spawning downstream of the barrier, and migratory fish may rarely gain access to the upper creek under unusual conditions. It is believed that only a few migratory adults use the section of Troublesome Creek downstream of the barrier, since there is a limited amount of spawning and rearing habitat. Although connectivity with other local populations within the system is considered poor, this is the natural condition of this particular local population. Recent genetic work indicates that the native char in this system are all bull trout (Young, pers. comm. 2004), while prior meristic and morphological data suggested that some were potentially Dolly Varden (Kraemer 1994).

In Salmon Creek, migratory-sized adult bull trout have been observed in the mainstem near the confluence with South Fork Salmon Creek during the spawning period (David Evans and Associates and R2 Resources Consultants 1998b). Juveniles have also been observed in the lower reach of the mainstem (David Evans and Associates and R2 Resources Consultants 1998b). Specific spawning areas in this system have not yet been identified, however available spawning and early rearing habitat is considered to be in good to excellent condition. The spawner abundance within this local population is currently unknown.

In the South Fork Skykomish River, an increasing number of migratory adult bull trout are trucked around Sunset Falls annually. The only known spawning areas are the lower East Fork of the Foss where tagged adults were tracked in 1993 (WDFW 1998), and more recently the Beckler River between river miles 2.0 and 5.0. The presence of resident fish is unknown, however, the migratory population of adult spawners currently numbers about 50 fish a year (Table 3). This population represents an expansion of the historical range of migratory bull trout in the Snohomish-Skykomish basin, with colonization

Table 3. Bull trout redd counts in the North Fork Skykomish River spawning index area, and bull trout adult counts at the Sunset Falls trap on the South Fork Skykomish River, 1988 to 2002 (Kraemer, *in litt*. 2001c).

Year	Number of Redds	Number of Adults
1988	21	--
1989	49	--
1990	67	--
1991	156	--
1992	82	--
1993	159	--
1994	*	18
1995	75	40
1996	60	45
1997	170	42
1998	177	47
1999	110	45
2000	236	51
2001	319	62
2002	538	90

*** incomplete survey**

occurring within the last few decades. Continued use of this area by migratory fish is dependent upon the ongoing operation of the trap and haul facility at Sunset Falls. Genetic samples from these returning adults have been collected and are awaiting analysis. Spawning and early rearing habitat is considered to be in good to excellent condition based on assessments from local biologists.

The mainstem corridors on the Snohomish, North Fork Skykomish, South Fork Skykomish, and Snoqualmie Rivers, and many of their accessible tributaries, provide important foraging, migration, and overwintering habitat for subadult and adult bull trout in this system. The anadromous component within this core area appears to be much more abundant than the fluvial component. Fluvial fish are generally confined to a few large pools found in the middle portion of the mainstem Skykomish River. In contrast, anadromous bull trout can be found throughout the anadromous reaches of the Snohomish-Skykomish River system. Juvenile and subadult life stages forage throughout the mainstem, but occasionally may be found using tributary streams. For example, a juvenile bull trout was observed in Trout Creek during 1998 stream surveys (David Evans and Associates and R2 Resource Consultants 1998c), while two adults were observed in Trout Creek' confluence pool with the North Fork Skykomish River (David Evans and Associates and R2 Resource Consultants 1998a). Subadults are believed to typically overwinter in the mainstem reaches of the Snohomish River. Recent tagging information indicates that subadults observed in the mainstem reaches may include fish from populations outside of the Snohomish core area (Goetz, pers. comm. 2002). The anadromous subadult and adult life stages spend much of the growing season (late winter to fall) in the estuary and nearshore marine waters of Possession Sound and Port Susan.

A spawning index, established by the Washington Department of Fish and Wildlife, has been used to track the overall status of bull trout in the Snohomish-Skykomish system. This index reach encompasses the upper North Fork Skykomish River from river mile 15 to 18.5, including Goblin Creek up to river mile 0.5 and the lower portion of West Cady Creek. Spawner abundance (number of redds) have been tracked annually since 1988 (WDFW 1998) (Table 3). Assuming an intermediate value of 2.5 spawners per redd based on sex ratios reported in other systems (Goetz 1989; Brown 1994; McPhail and Baxter 1996; James and Sexauer 1997), the average number of redds counted over the last six years (258), when counts exceeded 100 redds annually, suggest the average annual spawner abundance in the North Fork Skykomish index reach is around 650 individuals. The average number of redds counted for the past 10 years of record is 188, which would suggest a 10-year average of 470 individuals. Population monitoring also occurs at the trap and haul facility at Sunset Falls. All adult bull trout entering the trap are counted and released above the falls (Table 3). Numbers of adult bull trout passed into the South Fork continue to increase, and new spawning and rearing areas are being colonized. It is believed that this local population will exceed 100 adult spawners in the near future. Based on increasing abundances (approximately a three-fold increase in spawner abundance since 1990), the Washington Department of Fish and Wildlife has rated this population as healthy. With this increase in abundance, fishing continues to be allowed in this system (two fish limit with a 508 millimeter (20 inch) minimum size limit).

Chester Morse Lake core area. The Chester Morse Lake core area is located within the Cedar River Municipal Watershed in the upper reaches of the Cedar River drainage, upstream of a natural migration barrier at Lower Cedar Falls (river mile 34.4) (Figure 9). The municipal watershed serves as the major source of water for the City of Seattle and surrounding communities, and has had restricted public access since 1908 to maintain high water quality. The Chester Morse Lake core area has a drainage area of 214 square kilometers (83 square miles). The largest water body in the upper Cedar River watershed is the Chester Morse Lake/Masonry Pool reservoir complex, which is approximately 10.7 kilometers (6.6 miles) in length. Chester Morse Lake (originally Cedar Lake) was naturally formed by glaciers and is approximately 8.4 kilometers (5.2 miles) long and 1 kilometer (0.6 mile) wide. The water elevation of the lake was raised 9.8 meters (32 feet) following the construction of Masonry Dam to provide storage for the City of Seattle's municipal water supply and hydroelectric power generation.

Chester Morse Lake currently has a maximum depth of approximately 41.1 meters (135 feet) at full pool. The western end of the reservoir complex, Masonry Pool, is connected to Chester Morse Lake by a narrow channel flowing through a lateral glacial moraine. Masonry Pool is physically separated from Chester Morse Lake during periods of drawdown by a small concrete dam (Overflow Dike). The two major tributaries flowing into Chester Morse Lake are the upper Cedar River and the Rex River. Although the ‘canyon reach’ between Lower Cedar Falls and the Masonry Dam is included in the core area, it is not considered to be suitable bull trout habitat or capable of supporting a sustainable population because it is dominated by a series of waterfalls, bedrock chutes, and large plunge pools that severely restrict any appreciable upstream movement and/or interchange within the reach.

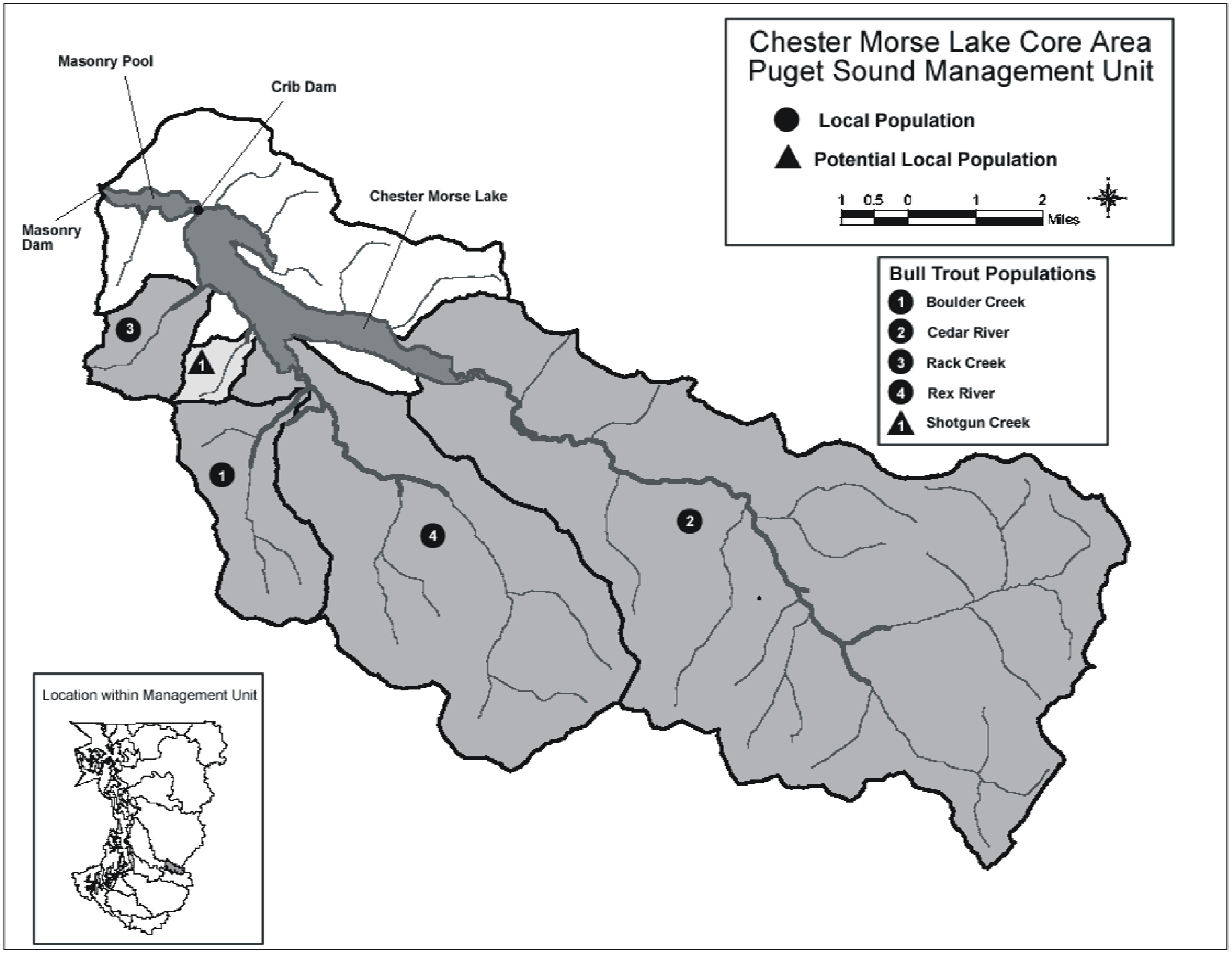

Figure 9. Chester Morse Lake core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

The Cedar River watershed upstream of the Masonry Dam supports the only known self-sustaining population of bull trout in the Lake Washington basin. Identification of char in this core area to date has been based on morphometric and meristic measurements that strongly indicate they are bull trout (City of Seattle 2000a). Genetic samples were collected from juvenile fish (1+ year class[†]) rearing in the Cedar and Rex River mainstems, selected tributaries to these streams, and a tributary to Chester Morse Lake, Rack Creek, during the 2002 field season and will be submitted for analysis (Paige, *in litt*. 2003).

The presence of bull trout in the Chester Morse Lake core area has been documented in Chester Morse Lake and Masonry Pool and in some tributaries to Chester Morse Lake, including the Cedar and Rex Rivers (City of Seattle 2000a). In addition, Seattle Public Utilities staff have documented the presence of bull trout in Rack and Shotgun Creeks, tributaries to Chester Morse Lake; in Boulder, Cabin, and Morse Creeks, one unnamed side channel to the Rex River (upstream of the 300 Road), and in the lowermost reach of Lindsay Creek (Boulder Creek tributary); in Eagle Ridge Creek and several floodplain channels of the Cedar River, and one small, unnamed northside tributary of the upper Cedar River downstream of the North and South Forks and the 600 Road bridge (Paige, *in litt*. 2003). The upstream terminus of the documented bull trout distribution in most of these streams has been established up to natural passage barriers (*e.g*., Rex River, Lindsay Creek, North Fork Cedar), but has not been definitively established in several others (*e.g.*, South Fork Cedar, Boulder Creek) (Paige, *in litt*. 2003). In addition, the presence of bull trout has not been detected in several streams thought to exhibit habitat characteristics suitable to support them (*e.g.*, Bear Creek, upper South Fork Cedar, Bridge Creek) (Paige, *in litt*. 2003). Field surveys to expand the documented range of bull trout within the Chester Morse Lake core area will be continued by Seattle Public Utilities staff under elements of the City of Seattle’s Habitat Conservation Plan (see Appendix 4 for a definition of habitat conservation plan) for the Cedar River Watershed (City of Seattle 2000b; Paige, *in litt*. 2003).

Within the Chester Morse Lake core area, in addition to Chester Morse Lake and Masonry Pool, the presence of bull trout has been confirmed in a total of 36.6 kilometers (22.7 miles) of streams. Of that total, 15.9 kilometers (9.9

miles) are in the mainstem of the Cedar River, 6.0 kilometers (3.7 miles) are in the mainstem of the Rex River, 1.3 kilometers (0.8 mile) are in the North Fork Cedar, and 1.1 kilometers (0.7 mile) are in the South Fork Cedar (upper limit not determined). The remaining bull trout habitat is found in smaller tributaries of the Cedar (8.8 kilometers; 5.4 miles) and Rex (5.5 kilometers; 3.3 miles) systems and in tributaries of Chester Morse Lake (0.6 kilometer; 0.4 mile).

The level of emigration of bull trout occurring from Chester Morse Lake to the lower Cedar River is unknown. The only means for bull trout to leave the reservoir complex and pass to the lower Cedar River is during use of the emergency spill gates and/or the smaller spillway[†] near the south end of the Masonry Dam. These gates are rarely opened except under emergency conditions of high reservoir elevation (*e.g.*, 1990 flood) or for special operational purposes. It is presumed impossible for live fish to pass through the other structure used to release water from Masonry Pool (Masonry Dam spill valve/Howell-Bunger Valve) at the base of the Masonry Dam. It is possible, however, and in fact probable, that bull trout do successfully pass through the spill gates when water is released and thereby gain access to the ‘canyon reach’ and the lower Cedar River, but no accurate estimate of numbers of fish passing the dam can be determined.

As of 2000, no substantive evidence has indicated that either a self-sustaining population of bull trout or any significant number of individuals exists in the approximate 20 kilometers (12.5 miles) of mainstem, or additional tributary habitat, between the Masonry Dam and the Landsburg Diversion Dam. Although passage over the Masonry Dam, and subsequent downstream movement, of a limited number of bull trout is expected to occasionally occur during seasonal spillway releases of water from Masonry Pool as indicated above, it apparently has not been sufficient to support establishment of bull trout populations under the ecological conditions existing in downstream reaches (City of Seattle 2000b). One incidental sighting of a single adult char (assumed to be a bull trout) immediately upstream of the powerhouse at Cedar Falls was reported during September 1997 (K. Binkley, Seattle City Light, pers. comm. 1997). A second sighting of three adult char (assumed to be bull trout) was reported during July 2000 in one of the powerhouse tailraces[†] at Cedar Falls (E. Ablow, Seattle City Light, pers. comm. 2000). These individuals were estimated to be approximately

254 to 305 millimeters (10 to 12 inches) in length and exhibited some signs of recent, non-lethal injury on their heads and dorsal surfaces (Paige, *in litt*. 2003). A third sighting of three adult char (assumed to be bull trout) was reported during August 2003 in the powerhouse tailrace at Cedar Falls (E. Ablow, Seattle City Light, pers. comm. 2000), but these may have been the same individuals as observed previously in July. No other sightings of bull trout are currently known from the Cedar River between Cedar Falls and Landsburg. A few incidental sightings, however, have been reported from the Landsburg to Lake Washington reach of the lower river (see Lake Washington foraging, migration, and overwintering habitat).

The only sexually mature bull trout that have been observed to date in the Cedar and Rex Rivers are spawning adults that have migrated upstream from Chester Morse Lake. Consequently, local populations of bull trout in this core area appear to be primarily, if not completely, composed of adfluvial life history forms. There remains, however, the possibility that resident and/or fluvial life history forms may be present in some upper reaches of the North and/or South Fork of the Cedar River downstream of natural passage barriers.

Bull trout in the Chester Morse Lake core area have exhibited a consistent pattern of spawning habitat use since studies were initiated during the early 1990's (Paige, *in litt*. 2003). The most densely and consistently utilized bull trout spawning reaches during the last decade are located in mainstem reaches of the Cedar and Rex Rivers, within approximately 2.9 kilometers (1.8 miles) and 1.1 kilometers (0.7 mile) of the reservoir, respectively, and in several floodplain channels of the Cedar River upstream of the Camp 18 bridge (City of Seattle 2000a; Paige, *in litt*. 2003). Each of these reaches contains large concentrations of gravel relative to other upstream reaches of the Cedar and Rex River systems; both substrate size, and in most cases gradient, increase immediately upstream of these ‘core’ survey reaches (Paige, *in litt*. 2003). Redds are distributed throughout these reaches in varying density and patterns of distribution from year to year, however, the vast majority of observed use has been concentrated in these same areas during all years of survey (Paige, *in litt*. 2003).

A relatively low level of bull trout spawning activity has been detected in several limited reaches of the Cedar River upstream of the 'core' survey reaches near Chester Morse Lake. Between Roaring Creek and Seattle Creek, spawning was discovered by redd surveys (City of Seattle 2000a). Fry trapping (fyke nets) conducted between the confluences of Seattle and Bear Creeks indicates that some relatively low level of bull trout spawning activity has taken place upstream of that point (Paige, *in litt*. 2003). Limited evidence (unconfirmed redds) has suggested some potential for isolated spawning activity (in pocket gravels) a short distance downstream of the 600 Road bridge located at river mile 51.4. This area is 1.4 kilometers (0.9 mile) downstream of the confluence of the North and South Fork of the Cedar River. No indications of bull trout spawning activity upstream of this reach (upstream of the 600 Road bridge) have been observed. The river upstream of this location is dominated by large cobbles and boulders, while spawning gravels upstream of this location are scarce (City of Seattle 2000a). Bull trout spawning in the Rex River has been observed upstream only as far as 122 meters (400 feet) downstream from the confluence of Morse Creek. Upstream of Morse Creek, the reach of the Rex River that extends approximately 2,921 meters (9,582 feet) upstream to Lindsay Creek becomes narrow and substantially higher in gradient and is dominated by large cobbles and boulders. Most reaches of the Rex River within a short distance upstream of the confluence of Lindsay Creek are dominated by bedrock substrates and bedrock intrusions that result in a series of barriers which are impassable to fish. The first barrier is a large falls 354 meters (1,160 feet) upstream of the confluence of Lindsay Creek (Paige, *in litt*. 2003).

Based upon spawning surveys conducted in the upper Cedar River watershed since 1992, it appears that the population of bull trout spawners in this core area may vary considerably from year to year, although both environmental conditions (*e.g.*, high stream flows) and field logistics (*e.g.*, lack of field staff, organizational priorities, documenting extent of habitat usage, etc.) have substantially influenced at least some of the redd counts, especially those conducted prior to the 2000 season. The level of effort (repeated surveys) invested in redd surveys during years prior to 2000 was typically several magnitudes (2 to 5 times) less than the effort expended during and after 2000. Prior to 2000, surveys were not typically conducted on a regular (weekly or biweekly) schedule and in several years were concentrated in only one month (*e.g.*, October, November) of the spawning season as it is now defined (September to January). In several of these years, the majority or all of the surveys were conducted during October, presumably prior to the peak activity period (early November) as indicated by data from more extensive survey years. For example, the highest number of bull trout redds observed (110) prior to year 2000 was in 1993 when all surveys were conducted during the period November 1 through November 21 (City of Seattle 2000a). Because surveys were not conducted prior to November, nor during December and January, it is possible that a substantial number of redds may not have been detected and counted, even though all surveys were conducted during the month of peak spawning activity.

Total redd counts for the core area including the major tributaries, Cedar and Rex Rivers, and all mainstem and lake tributaries from 1992 to 2002 have ranged from 6 to 504 redds per year (WDFW 1998; City of Seattle 2000a; City of Seattle 2000b; Paige, *in litt*. 2003). The lowest redd counts were recorded in 1995 and 1996 with fewer than 10 redds recorded per year, however these particular counts are considered incomplete survey years due to lack of access to streams and substantial periods of marginal survey conditions during high flows and late season floods. Emigrant fry trapping, however, following each of these low spawning count years (1996 – 0 fry captured; 1997 – 15 fry captured) were not inconsistent with low levels of spawning activity (City of Seattle 2000b). Low levels of fry capture are potentially an indication of low spawning activity and/or loss of redds due to extensive substrate scour, as was probably the case in 1996 after extended periods of peak flows (Paige, *in litt*. 2003). Not capturing fry in 1996 with levels of effort similar to years in which fry were readily captured suggests that the entire year class may have been lost due to the extent of substrate scour incurred during peak flow events in the system. Such complete production losses (or low production years) in any given year have presumably occurred periodically as the result of natural causes as bull trout have evolved in this core area. Their persistence despite such catastrophic losses (*e.g.,* of an entire age class) is at least some indication of the stability of this core population[†].

In comparison, surveys documented totals of 236 bull trout redds in both fall 2000 and fall 2001, and 504 bull trout redds in year 2002 in the Chester

Morse Lake core area (Paige, *in litt*. 2003). These 3 years of survey data were collected under nearly ideal field survey conditions with sufficient field staff to provide complete coverage of ‘core’ spawning reaches on a consistent (*i.e.*, weekly) basis throughout the spawning season and between successive years. These more recent data may therefore present a much more valid picture of the capacity of the bull trout population than that presented by much of the early survey data. This is believed to be the case considering that in a year (2002) with some of the lowest recorded stream flows for the system and near record low lake levels in the reservoir, bull trout were able to access typical spawning reaches in both the Cedar and Rex Rivers throughout the spawning season and spawn in record numbers.

Based on earlier gill net data (Wyman 1975) and more recent hydroacoustic data collected from 1993 to 1994, the minimum bull trout population in Chester Morse Lake was estimated to be about 3,100 adult fish, and one half of these fish were considered to be sexually mature (City of Seattle 2000a). Based on these population estimates and data from Flathead Lake indicating an average of 57 percent (range 38 to 69 percent) of the adult-sized bull trout in Flathead Lake spawn annually, and that there are 3.2 fish per redd (Fraley and Shepard 1989), it is estimated that 884 (range 589 to 1,070) bull trout could be expected to move into tributaries of Chester Morse Lake to spawn (City of Seattle 2000b). From this estimate of potential bull trout spawners, a prediction of 276 (range 184 to 334) bull trout redds could be expected in the Chester Morse Lake core area. Although earlier redd counts fell well below this range, recent redd counts during the period 2000 to 2002 (236 redds in 2000, 236 redds in 2001, and 504 redds in 2002) fall either in the middle or significantly exceed the predicted range (Paige, *in litt*. 2003). If it is assumed that there are 2.5 fish per redd (Goetz 1989; Brown 1994; McPhail and Baxter 1996; James and Sexauer 1997), the estimated number of potential redds would be 353 (range 235 to 428) and as above, the recent redd survey counts for the core area fall within the predicted range, or in the case of year 2002, substantially exceed the highest predicted count.

Bull trout redds located in lower portions of areas of concentrated bull trout spawning activity, especially in the Cedar and Rex Rivers, as well as extreme lower reaches of Boulder Creek and Cabin Creek (tributaries to Rex River) and smaller lake tributaries (*e.g.,* Shotgun Creek, Rack Creek), are subject to varying degrees of inundation (*i.e.*, depth and duration of inundation) during periods of late winter/early spring reservoir refill. It is currently unknown, however, whether redd inundation causes any mortality, or otherwise causes any significant effects to eggs and/or alevins[†] in either the Cedar or Rex systems. It is significant to note, however, that adults have consistently returned to traditional spawning reaches in both the Cedar and Rex systems on an annual basis and persisted in the Chester Morse Lake core area over a period of 100 years of widely variable reservoir fill and drawdown regimes. The City of Seattle plans to evaluate the potential impact of redd inundation in studies planned as part of their habitat conservation plan (City of Seattle 2000b).

Bull trout have also been documented to spawn in small numbers (*i.e.*, usually fewer than 10 redds per year) in Boulder Creek, a tributary to the Rex River, and in Rack Creek, Shotgun Creek, and Damburat Creek (single redd; early 1990's), which are tributaries to Chester Morse Lake (Paige, *in litt*. 2003). Spawning activity in Rack Creek and Shotgun Creek has been limited to within a few hundred meters/yards of their confluence with the reservoir, only downstream of the perimeter forest road (200 Road) in the case of Shotgun Creek and up to 270 meters (885 feet) upstream of the road in the case of Rack Creek. A natural passage barrier is present in Rack Creek approximately 457 meters (1,500 feet) upstream of the perimeter forest road. Although limited spawning activity in Rack Creek has been consistent from year to year, activity in Shotgun Creek has been somewhat sporadic. Both of these creeks consistently experience one or more periods of subsurface flow each year, typically during the hottest and/or driest summer periods.

Such subsurface flow can also be influenced and/or caused by low reservoir levels in that flows are subsurface at the confluences with the reservoir and therefore present barriers to fish either entering or exiting the upstream reaches. Subsurface flow conditions are most commonly and consistently observed in reaches downstream of the perimeter forest road (200 Road), but have routinely been observed to extend to upstream reaches of Rack Creek as much as 76 to 91 meters (250 to 300 feet) upstream of the road. Subsurface flow conditions have not been observed in Shotgun Creek upstream of the perimeter forest road (200 Road) in more than two decades (Paige, *in litt*. 2003). Similar subsurface flow conditions are consistently observed and exaggerated in Lost Creek, the only tributary to Masonry Pool, downstream of the 202 Road, and no bull trout spawning or rearing has been observed in the tributary (Paige, *in litt*. 2003). Such annual subsurface flow conditions may be problematic to both adult and/or juvenile bull trout in that flow conditions can present conditions that prevent both ingress and/or egress by either adults and/or juveniles or that isolate individuals of any age class within barriers, which in many cases may result in mortality. Other southside tributaries to Chester Morse Lake have natural gradient barriers at their confluences with the reservoir and are not accessible to fish (*e.g.*, Echo Creek, Snowshoe Creek).

Prior to 1992, bull trout were restricted to the lowermost reaches of Rack Creek. These reaches experienced subsurface flow conditions annually, and may have resulted in mortality of a substantial number, if not all, of the bull trout fry and juveniles produced in the drainage. In 1992, fish passage was restored to the upper reaches by removal of blocking culverts. Currently, despite experiencing subsurface flow conditions in the lowermost reaches, juvenile bull trout utilizing Rack Creek appear to be able to consistently pass upstream of the bridge and access and persist in wetted refuges upstream of portions of the channel that become dewatered. Fish surviving in these reaches are subsequently able to reoccupy downstream reaches and migrate to Chester Morse Lake under favorable flow conditions (Paige, *in litt*. 2003). Similarly, bull trout rearing in Shotgun Creek have for decades been confined to lower reaches that dewater annually at a passage barrier (perched culverts) at the perimeter road (200 Road). Similar to the historical condition in Rack Creek, many, if not all, of the bull trout fry and/or juveniles produced in those reaches may have perished, at least in some years. However, this barrier was removed in 2001 and a concrete box culvert (bridge) was installed to restore fish passage. It has not yet been confirmed whether bull trout have recolonized reaches upstream of the forest road (200 Road), but it is expected that juvenile bull trout produced in this system will soon be able to access upstream reaches of Shotgun Creek, rear in reaches that retain flow year-round, and be able to migrate to Chester Morse Lake under favorable flow conditions as is currently the case in Rack Creek (Paige, *in litt*. 2003).

Incidental observations of juvenile bull trout captured and released during efforts to collect genetic samples in 2002 indicated they are surprisingly mobile in small tributary streams, with one individual moving a minimum of 152 meters (500 feet) upstream during a 1- to 2-day period (Paige, *in litt*. 2003). Large woody debris restoration projects were completed in the lowermost reaches of Shotgun Creek and Lost Creek during 2002 to improve both hydraulic stream function and instream habitat (Paige, *in litt*. 2003).

Similar to the conditions described above for southside creeks, tributaries entering Chester Morse Lake on the north side (including Otter Creek, Bridge Creek, Green Point Creek, and McClellan Creek) all experience similar subsurface flow conditions over some portion of their length, especially after they reach the valley bottom floor. In addition, each creek is similarly influenced by low reservoir levels on a seasonal basis. Habitat in these streams is severely limited, especially by steep gradient, aggradation[†] of substrates in some of their reaches, and substantial bedload[†] movement in others. The presence of bull trout has not been established in any of these tributary streams (Paige, *in litt*. 2003). Damburat Creek also experiences subsurface flow conditions, especially at low lake levels, and access may also be frequently limited by extensive beaver activity in its reaches near the confluence with the reservoir. Observation of bull trout activity in Damburat Creek is limited to one potential redd in an early 1990's survey (City of Seattle 2000a).

Based on the spatial distribution of spawners observed in the Chester Morse Lake core area in the Cedar River Municipal Watershed, the Cedar and Rex Rivers are currently identified as the primary local populations for this core area. Small local populations are presumed to be present in Boulder Creek (a major tributary to the Rex River), Rack Creek, and possibly Shotgun Creek, based upon the relatively limited amount of spawning and rearing activity (see below) observed in these lake tributaries and their degree of spatial separation from other local populations. Although in recent years most bull trout redds observed in Boulder Creek have been located within 30 meters (100 feet) of the confluence with the Rex River and in close proximity to the reach of highest concentration of redds observed in the Rex system, some redds documented in earlier surveys (1992) were located as far as 976 meters (3,200 feet) upstream of the confluence

(226 meters [738 feet] upstream of the 200 Road). The overall distribution of redds observed in Boulder Creek is a preliminary indication that bull trout spawning in this creek may constitute a local population. A restoration project is being evaluated by Seattle Public Utilities staff for potential implementation during 2003 to 2005. This project would return the lower reaches of Boulder Creek back to a channel occupied prior to the peak flow events of the 1990's. This historical channel is thought to be of better habitat quality and less susceptible to reservoir inundation.

This core area appears to have one of the most extended spawning periods within the Puget Sound Management Unit, and potentially within the entire range of the species. The spawning period of bull trout in the upper Cedar River watershed extends from mid-September through December, with some fish observed spawning as late as mid-January (Paige, *in litt*. 2003). Spawning is typically observed from mid-October through mid-November, but peaked the first week of November in 2001 and 2002 (Paige, *in litt*. 2003). Spawning typically commences following the first major storms in the fall, and appears to be initiated by rapidly declining water temperatures and significant increases in streamflow.

Juvenile bull trout have been observed in the upper Cedar River drainage in the mainstem as far upstream as the natural passage barrier (*i.e.*, falls) on the North Fork Cedar River just upstream of the 500/530 Road Junction at river mile 52.2 (City of Seattle 2000a) and in the South Fork Cedar River drainage to the 500/600 Access Road, at the abandoned USGS weir that constitutes a seasonal fish passage barrier (no bull trout documented upstream of this reach) at river mile 52.1 (Paige, *in litt*. 2003). Seattle Public Utilities is investigating the feasibility of breaching and/or removing this structure under restoration elements of the Cedar River Habitat Conservation Plan. Juvenile bull trout have also been observed in the Rex River immediately upstream of the confluence of Lindsay Creek and in the lowest reach of Lindsay Creek (downstream of natural barrier) (Paige, *in litt*. 2003). In addition, juvenile bull trout have been documented in several wetlands and tributary streams fed from wetland systems including Eagle Ridge Creek and floodplain channels (Camp 18 area) on the Cedar system, and Cabin Creek and Morse Creek on the Rex system. Water temperatures in some of these floodplain channels range between 1 and 10 degrees Celsius (34 to 50 degrees Fahrenheit) on an annual basis (Paige, *in litt*. 2003).

Boulder Creek, although not fed from a wetland system, also supports juvenile bull trout rearing in the Rex River drainage. Juvenile bull trout are likely present in major tributaries to the Cedar and Rex Rivers that are accessible, but their presence has not yet been confirmed in some (*e.g.*, Bear Creek). The presence of juvenile bull trout has been confirmed consistently in Rack Creek but only sporadically in Shotgun Creek. Both of these streams are tributaries to Chester Morse Lake and are subject to the seasonal subsurface flow conditions described above. The observed variability in the presence/absence of juvenile bull trout may, at least to some degree, be a function of the need to 'recolonize' these streams after certain flow conditions create barriers to adult access and/or mortality of fry and juveniles rearing in these systems. Juvenile bull trout may also be present in other tributaries to Chester Morse Lake that are accessible to these life stages, but both habitat and seasonal flow conditions may be limiting factors in these types of streams (*e.g.*, Otter, Green Point, McClellan Creeks) where bull trout presence has not yet been confirmed (Paige, *in litt*. 2003).

The majority of bull trout in the upper Cedar and Rex River drainages are juveniles up to 3 years of age. Most juveniles captured in tributaries during electrofishing surveys are between 0 and 2 years of age (City of Seattle 2000b). Size distribution plots of bull trout captured (minnow traps) during 2002 in both the Cedar and Rex mainstems and several tributary streams demonstrated the presence of two distinct age classes (young-of-year and age 1+ fish)(H. Barnett, pers. comm. 2003).

Bull trout fry are typically evident throughout 'core' spawning survey reaches in both the Cedar and Rex River mainstems, as well as smaller tributaries (*e.g.*, floodplain channels) throughout late-winter and early spring. Based on visual observations, fry begin to emerge during a period that begins as early as February 22 and extends until late May (W. Belknap, Seattle Public Utilities, pers. comm. 2003). Some bull trout fry may emerge subsequent to this period, but are difficult to effectively detect after rainbow trout fry also begin to emerge at the end of May or in early June. Although a few bull trout fry as small as 23 millimeters (0.9 inch) have been observed, the smallest individuals that are captured most frequently are 25 millimeters (1 inch) in length, which should approximate typical total length of fry at or soon after emergence (Paige, *in litt*. 2003). Newly-emerged fry are typically observed in, and appear to favor, areas of low velocity flow, especially in mainstem reaches where they occupy habitat exhibiting a variety of substrate types including fine sediment, sand, and small to medium size gravel. At this stage, bull trout fry experiencing disturbance tend to seek refuge in channel substrates and channel margins and rarely retreat to deeper and faster flowing water (Belknap, pers. comm. 2003). Bull trout fry and rearing juveniles have been observed to extensively use small groundwater channels in the Cedar River floodplain, especially in the reach located upstream of the Camp 18 Bridge (100-300 Access Road) (Paige, *in litt*. 2003). These small streams may provide important refuge habitats to bull trout fry from peak flows and predators, as well as possess the cold water temperatures required by fry (Goetz 1997). Bull trout fry appear to be most mobile in mainstem reaches of the Cedar River in mid- to late April with a peak of activity around the 24th day (City of Seattle 2000b). The activity peak in the Rex River system appears to occur from 1 to 2 weeks later relative to the Cedar system (in early May) (City of Seattle 2000b), and may be related to differences in basin size, aspect, timing of snow melt, resultant flow levels, and water temperature differences. Bull trout fry have been observed in the mainstem Cedar River as far upstream as the reach between the confluences of Seattle Creek and Bear Creek (river mile 48.8).

Most bull trout in Chester Morse Lake and Masonry Pool are subadults and mature adults, based upon age analysis using otoliths[†]. Approximately one half of the fish sampled in the lake system were subadults (3 and 4 years of age), and the other half were sexually mature adults, generally 5 years of age and older (City of Seattle 2000a). Adult bull trout in Chester Morse Lake can exceed 12 years in age, but generally do not exceed 650 millimeters (25.6 inches) in total length. The age-structure of bull trout in this lake may be influenced by the absence of fishing pressure, since public access to this lake has been restricted for over 90 years. Juvenile bull trout have been observed in Chester Morse Lake during snorkel surveys, but appear to be restricted to the shallow margins of the lake (City of Seattle 2000a).

Chester Morse Lake and Masonry Pool provide the foraging, migration, and overwintering habitat for subadult and adult adfluvial bull trout in the Chester Morse Lake core area. Reservoir levels vary both between and within seasons, although the most substantial differences are exhibited between major seasons (*e.g.*, spring refill and fall drawdown). Seasonally fluctuating reservoir levels alter the surface area of the lake, exposing or inundating varying degrees of the littoral zone[†], especially in low gradient delta areas. The type and relative amount of habitat available to bull trout therefore change constantly and the type and availability of food resources vary accordingly and are dependent upon the integrated effects of all prevailing environmental conditions. Bull trout in Chester Morse Lake and Masonry Pool forage on a wide variety of food items, including invertebrates, salamanders, sculpin, juvenile rainbow trout, and pygmy whitefish. The most important food item to the largest bull trout in this lake system is pygmy whitefish. Chester Morse Lake possesses the largest population of pygmy whitefish in western Washington (City of Seattle 2000a).

Puyallup core area. The Puyallup core area contains the southernmost population of bull trout in the Puget Sound Management Unit. This core area is critical to maintaining the overall distribution of migratory bull trout within the management unit, since it is the only anadromous bull trout population in south Puget Sound. The Puyallup core area consists of several major watersheds draining the north and west sides of Mount Rainier. This glacial source significantly influences both water and substrate conditions in the mainstem reaches of this drainage. The core area includes the Puyallup, Mowich, and Carbon Rivers and their tributaries, and the White River including the Clearwater, Greenwater, and West Fork White Rivers, as well as Huckleberry Creek (Figure 10). Both anadromous and fluvial/resident bull trout local populations have been identified in the White River and Puyallup River systems, which converge in the lower basin at river mile 10.4 of the Puyallup River. Limited information is available regarding the distribution and abundance of bull trout in this core area. Observations of bull trout have generally been incidental to other fish survey work. Glacial turbidity creates limited opportunities and sites to survey for bull trout in this system. Five local populations have currently been identified for this core area: the upper Puyallup and Mowich Rivers; Carbon River; upper White River; West Fork White River; and Greenwater River. In addition, one potential

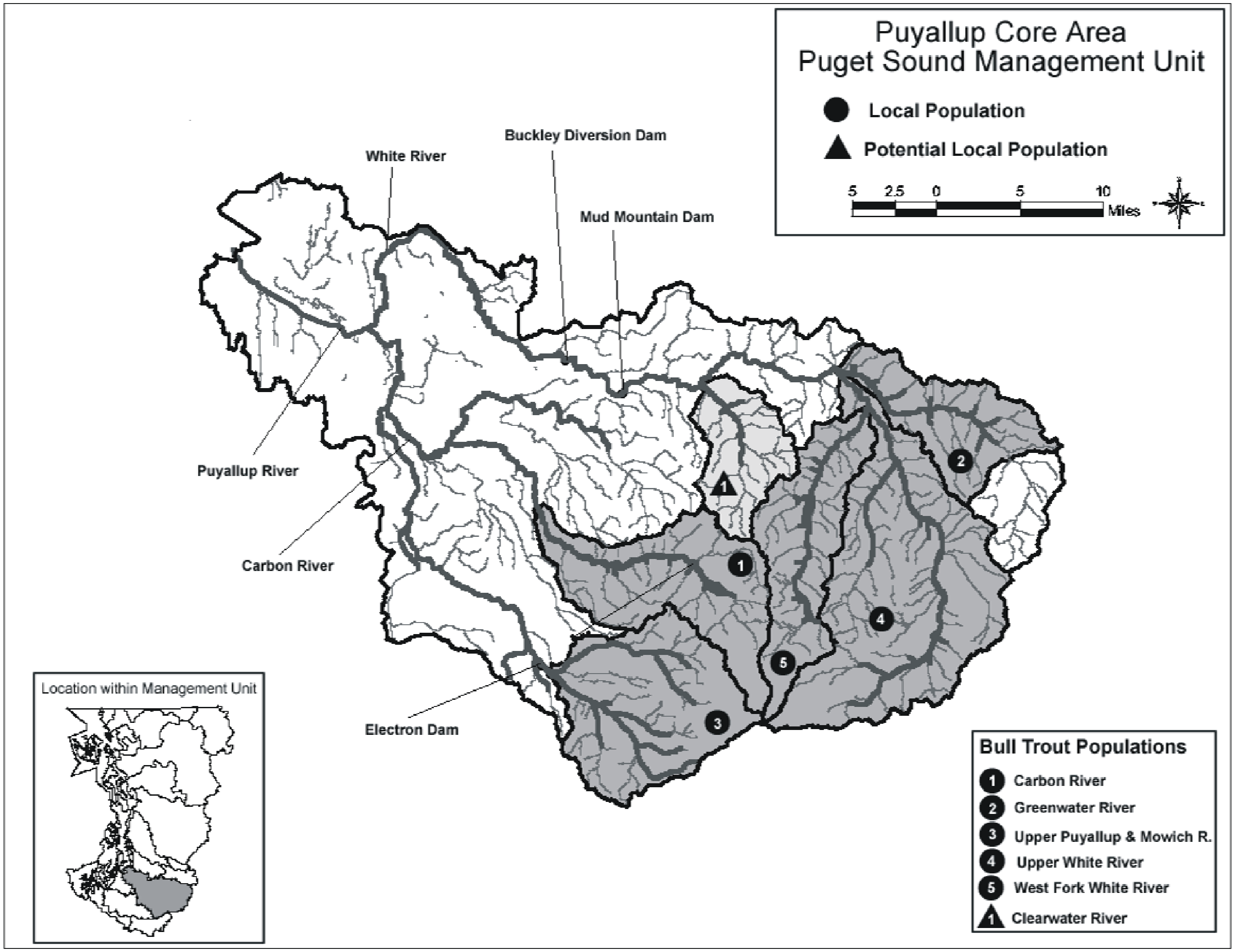

Figure 10. Puyallup core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

local population, Clearwater River, has also been identified; although part of the current bull trout distribution, there is currently insufficient information to determine if reproduction is occurring here.

Spawning occurs in the upper reaches of this basin where higher elevations produce the cool temperatures required by bull trout. Based on current survey data, bull trout spawning in the Puyallup core area appears to occur earlier (September) than what has typically been observed within other Puget Sound core areas (Marks *et al*. 2002). Rearing is believed to occur throughout the rivers listed above, however sampling indicates that a majority of the rearing is confined to the upper reaches of the basin. The Puyallup Tribal fisheries in the lower Puyallup River and the U.S. Army Corps of Engineer's Buckley trap commonly intercept large migratory bull trout, indicating that an anadromous life history is present in this system (Hunter, *in litt*. 2001). In addition, bull trout have been confirmed in tidewater areas of the lower Puyallup River (Baker and Moran 2002; Puyallup Tribe, *in litt*. 2003). Primary foraging, migration, and overwintering habitat for migratory bull trout within the core area is believed to be the mainstem reaches of the White, Carbon, and Puyallup Rivers. The anadromous life history form is believed to use Commencement Bay and likely other marine nearshore habitats along Puget Sound. Many of the headwater reaches of the basin are within either Mount Rainier National Park or designated Wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) providing pristine habitat conditions. However, a majority of the basin has been significantly altered by a variety of anthropogenic factors including extensive timber harvest and associated road construction; conversion of landscape to residential, commercial, and agricultural use; substantial channelization of lower mainstem reaches; and total commercial development of the estuarine habitat. These factors have undoubtedly reduced the overall productivity of bull trout and salmon populations in the basin.

The Puyallup River drains from Tahoma and the Puyallup glaciers on Mount Rainier and flows generally northwest to Commencement Bay. The Mowich River drains the North and South Mowich and Flett Glaciers and enters the upper Puyallup River at river mile 42.3. The Puyallup River diversion at river mile 41.7, which serves Puget Sound Energy's Electron facility, impacts bull trout through interception of downstream migrants. The Carbon River is the other major tributary draining the Carbon and Russel Glaciers, flowing generally westerly to join the mainstem Puyallup River.

The upper Puyallup and Mowich Rivers are located upstream from Puget Sound Energy's Electron Diversion Dam. The upstream impasse created by the dam has effectively isolated these fish from the rest of the basin for nearly 100 years (WSCC 1999b). Baker and Moran's (2002) analysis of six tissue samples collected at the Electron Diversion Dam confirmed all native char sampled to be bull trout. Due to their close proximity and the shared effects from the diversion dam, bull trout residing in these two reaches are considered a single local population. A recently constructed fishway has been in operation since October 2000 and is expected to significantly improve connectivity and genetic interaction with other local populations in other parts of the core area. However, there are still concerns regarding the downstream interception of bull trout at the diversion facility (G. Ging, U.S. Fish and Wildlife Service, pers. comm. 2003). The Puyallup River mainstem and upper South Puyallup River upstream of the diversion is an unconfined channel incising through ancient mudflow terraces. This reach is characterized by moderate to moderately steep gradient and generally fast riffle waters and dominated by boulder to rubble/gravel substrate. Downstream of the diversion the stream channel becomes generally more confined with moderate gradient and contains a significant canyon feature. The Mowich River is generally characterized as unconfined and braided with fast rapid/riffle areas and a few shallow pools. Substrate is largely rubble and gravels with a few boulder areas. Tributaries of both rivers are generally steep with fast riffles and cascades with larger boulder and rubble substrates. Specific locations of spawning populations have not been identified in this area. However, the lower portions of the South Puyallup River and St. Andrews Creek are known to be currently occupied. Upstream portions of those streams and Kellogg, Swift, Deer, Niesson and Kapowsin Creeks are presumed to be occupied, excluding upper Swift Creek. The lower South Fork Mowich River and mainstem Mowich River are currently occupied, and the North Mowich River is presumed occupied. Juvenile bull trout were observed during fish surveys conducted in 2000 (MRNP, *in litt*. 2001). As additional information is gathered on this complex of streams, this local population may be further subdivided in the future. The overall condition of available spawning and rearing habitat in this local population is currently unknown, although pristine conditions within Mount Rainier National Park provide some quality habitat. The overall abundance of this system is currently unknown.

The Carbon River drains the Carbon and Russel Glaciers flowing generally westerly to join the mainstem Puyallup River near river mile 18. All known reports of spawning bull trout in this watershed are confined to the upper Carbon River above the canyon at river mile 11 to 15, indicating a spatial separation from other populations in the core area. Therefore, the Carbon River is currently considered a local population. The upper river is characterized as unconfined, heavily braided channel with moderate gradient and dominated by cobble and gravel substrate. The lower Carbon River has moderate gradient with riffle/pool habitats and gravels suitable for spawning by salmonids. Most upper river tributaries are steep in nature with cascades and rubble substrate. Two lower river tributaries, South Prairie Creek and Wilkeson Creek, have steep headwaters and moderate gradient with productive fish habitat characteristics throughout their lower sections. Spawning populations have been identified in the Carbon River near river miles 20, 22 and 28. The presence of juvenile and subadult bull trout has been documented in the mainstem, lower Ipsut Creek, lower Chenuis Creek, and Ranger Creek (Samora, *in litt*. 1998; MRNP, *in litt*. 2001). In 1994, 16 bull trout were sampled incidentally to steelhead parr (juvenile fish) surveys, between river mile 18.6 and 22 on the Carbon River (WDFW 1998). These bull trout ranged from 112 to 310 millimeters (4.4 to 12.2 inches) in length. In 2000, Puyallup Tribal Fisheries conducted spawning surveys for the first time in Ranger Creek. Several redds, presumed by their size and timing to be from bull trout, were observed that year, however, no redds were observed in 2001 (Marks *et al*. 2002). Accessible upstream reaches of these creeks are presumed to be occupied.

The other accessible Carbon River tributaries located within Mount Rainier National Park (*e.g.*, June Creek, Falls Creek) provide near pristine and excellent conditions with ideal spawning and early rearing habitat. Unfortunately, this favorable habitat is limited to the park boundary, whereas tributaries downstream from the park do not provide the same favorable habitat. Tributaries immediately outside of the park in Snoqualmie National Forest (e.g., Poch Creek, Tolmie Creek) also provide potential spawning and/or rearing habitat. Bull trout have not been found in South Prairie Creek and Wilkeson Creek, however due to the relatively high salmonid production in these particular streams, they likely contribute significant forage for bull trout in the lower Puyallup River and Carbon River systems. Subadult and adult size bull trout have been caught by salmon anglers in the lower reaches of the Carbon River to its confluence with the Puyallup River (K. Reynolds, U.S. Fish and Wildlife Service, pers. comm. 2003). In March 2000, night snorkel surveys in the mainstem Carbon River between the top of the canyon reach (Fairfax Bridge) to the Mount Rainier Park entrance detected four bull trout between 305 to 457 millimeters (12 and 18 inches) in length, and six brook trout near the park entrance (Craig, *in litt*. 2000b). The overall abundance of the Carbon River local population is currently unknown. Connectivity to other local populations and forage areas is believed to be good, although the canyon reach in the Carbon River may present some short-term upstream migration delays. Some habitat diversity has been lost in the lower mainstem Carbon and Puyallup Rivers due to channel simplification, impassable culverts, and estuarine fill.

The major lower Puyallup tributary, the White River, drains the northeast portion of Mount Rainier and has extensive bull trout use in several tributaries: the Greenwater River, Clearwater River, and the West Fork White River. Mud Mountain Dam, completed in 1948, is a flood control structure in the lower White River located at river mile 29.6 and Puget Sound Energy’s Buckley diversion dam forms a barrier at river mile 24.2 just downstream. These two structures have historically been a problem for both downstream and upstream fish passage, but new fish screens installed in 1996 have helped improve passage. Storage of peak flows behind Mud Mountain Dam still results in a disruption of sediment routing and ultimate delivery to downstream reaches, however. This, in turn, results in prolonged high turbidity and increased concentrations of fine sediment in the substrate. Recent operational modifications of the Puget Sound Energy diversion system have increased base flows in the bypass reach, thereby increasing rearing habitat quantity and quality.

The upper White River drains Emmons, Inter, Winthrop and Frying Pan Glaciers on the northeast flank of Mount Rainier located in Mount Rainier

National Park. The White River then flows through the Mount Baker-Snoqualmie National Forest providing some suitable habitats. Similarly, the West Fork White River and Huckleberry Creek originate in Mount Rainier National Park and flow through the Mount Baker-Snoqualmie National Forest. The channels are generally steep, braided, and unstable. Cascades and fast riffles are dominant with a few pools and the substrate is largely boulder and rubble/gravel. Spawning in the upper White River has been documented near river mile 61 at Silver Springs Creek and in lower Klickitat Creek. Silver Springs Creek is a lower tributary to Silver Creek and parallels the White River. This short tributary (approximately 0.5 kilometer [0.3 mile] in length) runs directly through the Silver Springs campground, with spawning occurring throughout this reach. Only two redds were observed in 2001 (Marks *et al*. 2002). A peak count of 11 adults and 4 redds were recorded in Klickitat Creek on September 2001 downstream of the anadromous barrier located at approximately river mile 0.3 (Marks *et al*. 2002). Juvenile bull trout have also been observed in the pools and lateral habitats of this lower reach during surveys. A large adult migratory bull trout, approximately 508 millimeters (20 inches) in length, was observed in Huckleberry Creek in July of 1989 (E. Stagner, U.S. Fish and Wildlife Service, pers. comm. 2003). Spawning is presumed to occur in many of the accessible small tributaries within Mount Rainier National Park, since bull trout rearing has already been documented in a number of surveyed park tributaries including Sunrise Creek, Fryingpan Creek, Crystal Creek, and an unnamed tributary (stream catalog no. 0364) upstream of Klickitat Creek (MRNP, *in litt*. 2001).

The West Fork White River is generally steep, braided, and unstable. Cascades and fast riffles are dominant with a few pools and the substrate is largely boulder and rubble/gravel. Tributaries are steep and fast flowing with narrow channels and boulder to rubble/gravel substrate. Juvenile bull trout have been observed in Cripple Creek, Lodi Creek, and several other unnamed tributaries (stream catalog nos. 0226 and 0217) within Mount Rainier National Park (USFS, *in litt*. 1982; MRNP, *in litt*. 2001). Bull trout are presumed to also spawn and rear in lower Pinochle Creek, lower Hazzard Creek, and Viola Creek.

The Greenwater River enters the White River below river mile 46 and does not directly drain the glaciers off of Mount Rainier. Flowing from Castle

Mountain, the river drops rapidly for about 16 kilometers (10 miles) through a series of lakes within the Norse Peak Wilderness to near Pyramid Creek. Below Pyramid Creek to Burns Creek, cascades and fast riffles are dominant with a few pools and the substrate is largely boulder and rubble/gravel. The lower Greenwater River has reduced gradient producing good riffle pool characteristics with gravel substrates despite the obvious lack of large wood. The Greenwater River mainstem (Section 25), lower Pyramid, lower Slide, and “Midnight” (stream catalog no. 0126) Creeks are known to be used by bull trout (Stagner, pers. comm. 2003; USFS, *in litt*. 1990; USFS, *in litt*. 1991). George, Twenty-eight, Lower Foss, upper Pyramid Creeks, and two other unnamed tributaries (stream catalog No. 0124 and 0125) are presumed to support bull trout due to their accessibility. Steep-sided valley characteristics prohibit fish use of several other tributaries.

The Clearwater River flows from springs and runoff from Bear Head Mountain within the Clearwater Wilderness and flows northerly 16.9 kilometers (10.5 miles) to the White River at river mile 35.3. Upper sections of the Clearwater are characterized by steep gradients with cascades and fast riffles dominant with a few pools, substrate is largely boulder and rubble/gravel. Lower valley sections have a moderate to low gradient with gravel substrate. Bull trout have been identified in lower mainstem areas of the Clearwater system. In fall of 1998, a single adult bull trout approximately 400 to 450 millimeters (15.8 to 17.7 inches) in length was observed in the mainstem in close proximity to a redd (T. Nelson, Washington Department of Fish and Wildlife, pers. comm. 2003). However, it could not be determined whether this fish was spawning or foraging. Tributaries to the Clearwater River are steep and generally have impassable cascades a short distance upstream of their mouths. Bull trout are presumed to use the upper mainstem Clearwater to the natural barrier at river mile 6.2, as well as accessible tributaries such as lower Lyle Creek.

Connectivity of the White River local populations to other local populations and foraging and overwintering areas is fair to good depending upon trapping success and/or delays associated with the upstream migrant fishway at the Buckley diversion and the downstream migrant trap located in the Buckley diversion flowway. In fact, subadults are not typically trapped for upstream haul at the Buckley diversion due to the design of the trap. The U.S. Army Corps of Engineers operates the adult fish trap on the White River near Buckley as part of the Mud Mountain Flood Control Project. Records for bull trout that are trapped at the facility have been kept since 1987. These records show that numbers of bull trout trapped ranged from a low of 5 fish in 1992 to a high of 48 fish in 2000 (Table 4). The average for the years from 1990 to 2002 is 26 fish. Monthly counts at the trap show two peak counts, one occurring in August and the other in October. This information shows that bull trout migrate upstream in most months, but generally from May to early January. The Washington Department of Fisheries operated a downstream migrant trap in 1953, located on the bypass leading from the screens to the White River. Downstream juvenile/subadult bull trout migration, corrected for fish using the main channel, was estimated to be 693 bull trout between May and July of that year (Heg *et al*. 1953).

Table 4. Summary of annual counts of bull trout at the adult fish trap at Buckley Diversion Dam, 1990 to 2002 (USACOE 2003).

Year	‘90	‘91	‘92	‘93	‘94	‘95	‘96	‘97	‘98	‘99	‘00	‘01	‘02
Total	19	20	5	23	40	15	15	16	44	18	48	39	41

The Puyallup Indian Tribe recorded some length information for bull trout when they took scale and genetic samples at the Buckley fish trap. The information collected in 2000 found that bull trout lengths ranged from 340 to 560 millimeters, with a mean of 442 millimeters (13.0 to 22.0. inches; n = 56) (Marks *et al.* 2002). These lengths would be within the size range of anadromous bull trout as indicated by three bull trout caught in Commencement Bay with recorded lengths of 425, 508 and 565 millimeters (16.7, 20.0, and 22.2 inches) (Pacific International Engineering 1999). Young’s (1999) genetic analysis of 12 tissue samples provided by the Puyallup Tribe confirmed 11 of these fish to be bull trout, while Baker and Moran’s (2002) analysis of 104 tissue samples collected at the fish trap confirmed all sampled native char to be bull trout.

The individual status of each of these local populations within the White River system is currently unknown, however based on trap counts at the Puget

Sound Energy dam, at least the number of adult migratory bull trout transferred upstream into the White River system are known (Table 2). These numbers are extremely low relative to other anadromous core populations within the Puget Sound Management Unit. There is uncertainty as to whether these are primarily anadromous or fluvial migrants, however a number of the bull trout scale and length samples collected at the trap (Hunter, *in litt*. 2001) are comparable to that of anadromous forms sampled in the Lower Skagit River core area (Kraemer, *in litt*. 2003).

Samish River foraging, migration, and overwintering habitat. The Samish River foraging, migration, and overwintering habitat consists of the mainstem of the Samish River and Friday Creek. The Samish watershed is a relatively small drainage with approximately 46.7 kilometers (29 miles) of low gradient mainstem habitat and additional tributaries such as Ennis Creek which also provide accessible low gradient habitat. This is a productive river system supporting coho salmon, chum salmon, Chinook salmon, and steelhead and cutthroat trout which provide a forage base for anadromous bull trout. Adult and subadult bull trout have been caught on the mainstem Samish upstream of the confluence with Friday Creek as well as in the lower river, but potential use likely extends to the uppermost reaches of anadromous salmon use. In the past, most bull trout were observed during the winter steelhead season, primarily December through February (Kraemer, pers. comm. 2003c; D. Toba, Washington Department of Fish and Wildlife, pers. comm. 2003). This habitat is likely to be most heavily used by anadromous bull trout from the Nooksack and Skagit core areas due to their close proximity to this system. The Samish River enters Puget Sound at Samish Bay, between Bellingham Bay to the north and Padilla Bay to the south of Samish Island (which is no longer an island, as the former intertidal estuarine area was diked and drained in the late 1800's).

Lake Washington foraging, migration, and overwintering habitat. The Lake Washington foraging, migration, and overwintering habitat consists of the lower Cedar River below Cedar Falls, the Sammamish River, Lakes Washington, Sammamish and Union, the Lake Washington Ship Canal, and all accessible tributaries. The upper Cedar River Watershed above Cedar Falls, is a separate core area and not included in this description. Population status information, extent of use, and complete recovery value of this area is currently unknown. Adult and subadult size individuals have been observed infrequently in the lower Cedar River (below Cedar Falls), Carey Creek (a tributary to Upper Issaquah Creek), Lake Washington, and at the Hiram H. Chittendon (Ballard) Locks. No spawning activity or juvenile rearing has been observed and no distinct spawning populations are known to exist in Lake Washington outside of the upper Cedar River above Lake Chester Morse (see Chester Morse Lake core area).

The potential for spawning in the Lake Washington basin is believed to be very low as a majority of accessible habitat is low elevation, below 152 meters (500 feet), and thus not expected to have the proper thermal regime to sustain successful spawning. There are, however, some coldwater springs and tributaries that may come close to suitable spawning temperatures and that may provide thermal refuge for rearing or foraging during warm summer periods. These include Rock Creek (tributary to the Cedar River below Landsburg Diversion) and Coldwater Creek, a tributary to Cottage Lake Creek immediately below Cottage Lake. Coldwater Creek is a major temperature modifier for both Cottage Lake and Big Bear Creeks. Cottage Lake Creek below Coldwater Creek exhibits a much lower temperature profile than any other tributary to Big Bear Creek. High temperatures in Big Bear Creek are moderated by this flow to its confluence with the Sammamish River. Both Coldwater and Rock Creeks are relatively short, 1.6 to 3.2 kilometers (1 to 2 miles) in length, have high quality riparian forest cover, and are formed by springs emanating from glacial outwash deposits.

The upper reaches of Holder and Carey Creeks, the two main branches of Issaquah Creek, have good to excellent habitat conditions and may hold potential for bull trout spawning due to their elevation and aspect. However, despite survey efforts by King County (Berge and Mavros 2001; KCDNRP 2002), no evidence of bull trout spawning or rearing has been found. Holder Creek drains the eastern slopes of Tiger Mountain, elevation 914 meters (3,000 feet), and the southwestern slopes of South Taylor Mountain. Coho are found in Holder Creek up to an elevation of about 360 meters (1,200 feet) and cutthroat trout occur up to 427 meters (1,400 feet) in elevation.

Carey Creek originates at an elevation of roughly 700 meters (2,300 feet) in a broad saddle on the southeastern slopes of South Taylor Mountain. It is the only stream in the north Lake Washington/Sammamish drainage with a relatively recent (within the past 10 years) char sighting. The single observation of a pair of native char in the fall of 1993 (WDFW 1998) was about 0.8 kilometer (0.5 mile) downstream from an impassable, approximately 12-meter (40-foot) high falls, which is at an elevation of approximately 256 meters (840 feet). Thus the habitat in which this pair of char was observed was potentially too low in elevation for successful spawning. Upstream of the falls, significant numbers of resident cutthroat trout exist up to an elevation of approximately 396 meters (1,300 feet).

Aside from spawning, the Lake Washington drainage has both potential benefits and challenges to adult and subadult bull trout. Two large lakes with high forage fish availability are dominant parts of the lower watershed, and provide significant foraging habitat. A number of observations of subadult and adult sized bull trout have been made in Lake Washington (Shepard and Dykeman 1977; KCDNR 2000; H. Berge, King County Department of Natural Resources and Parks, pers. comm. 2003a). The connection with the Chester Morse Lake core area (population located in the upper Cedar River) is one-way only, and currently the level of connectivity with other core areas is unknown. Observations of bull trout in the Ballard Locks suggest migrations from other watersheds is likely occurring.

Bull trout have been caught in Shilshole Bay and the Ballard Locks during late spring and early summer in both 2000 and 2001. In 2000, up to eight adult and subadult fish (mean size 370 millimeters; 14.5 inches) were caught in Shilshole Bay below the locks between May and July. These fish were found preying upon juvenile salmon (40 percent of diet) and marine forage fish (60 percent of diet) (Footen 2000, 2003). In 2001, five adult bull trout were captured in areas within the Ballard Locks and immediately below the locks. One bull trout was captured within the large locks in June, and in May one adult was captured while migrating upstream through the fish ladder in the adult steelhead trap at the head of the ladder. Three adult bull trout were also captured below the tailrace during the peak of juvenile salmon migration on June 18 (Goetz, pers. comm. 2003).

Lower Green River foraging, migration, and overwintering habitat. Historically, bull trout were reported to use the Duwamish River and lower Green River in “vast” numbers (Suckley and Cooper 1860). In contrast, bull trout are observed infrequently in this system today. Prior to the permanent redirection of the Stuck River (lower White River) into the Puyallup River system in 1906 (Williams *et al*. 1975), the lower Green River system provided habitat for the spawning populations from the White River. Another factor that may have diminished the Green-Duwamish River system’s value for bull trout is the loss of the Black River due to construction of the Lake Washington Ship Canal in the mid-1910's. The Black River historically connected the Lake Washington Basin and Cedar River to the Green-Duwamish River system. Creation of the ship canal and Ballard Locks lowered Lake Washington by 2.7 meters (9 feet) and completely redirected flows of the Cedar River and Lake Washington tributaries to the canal (Warner 1996). The effect of these diversions was to leave the Green-Duwamish River system with only about a third of its original watershed (Parametrix and NRC 2000). Potentially this may have led to reducing its value for bull trout foraging and colonization.

Regardless, in recent times bull trout have been reported on the lower Green River as far upstream as the mouth of Newaukum Creek at approximately river mile 41, and are consistently reported in the lower Duwamish (KCDNR 2000; Berge and Mavros 2001; KCDNRP 2002). It is presumed that bull trout utilize the Green River up to the City of Tacoma’s Headworks Diversion Dam at river mile 61, which has been a barrier to upstream migration since 1912 (KCDNR 2000). It is not known for certain whether the bull trout observed in the lower Green River basin are foraging individuals from other core areas or if natural reproduction may still persist somewhere within the basin. Based on observed behavior from other systems within the management unit and the size of individuals typically reported, there is a strong likelihood that bull trout in the lower Green River are anadromous migrants from other core areas. Reports of historical use of tributaries in the lower Green River are rare, and there have been no recent observations (KCDNR 2000). Given their size and potential as a foraging area, tributaries such as Newaukum and Soos Creeks may occasionally be used by bull trout.

Bull trout occurrence in the Duwamish River has been documented several times over the past few decades. In April 1978, Dennis Moore, Hatchery Manager for the Muckleshoot Tribe, talked with three fishermen in the vicinity of North Wind Weir, river mile 7 of the Duwamish, and identified four fish as adult char (Brunner, *in litt*. 1999a). One adult bull trout was observed near Pier 91 in May 1998 (Brunner, *in litt*. 1999b). In 2000, eight subadult bull trout were captured in the Duwamish River at the head of the navigation channel at the Turning Basin restoration site at river mile 5.3. These fish averaged 299 millimeters (11.8 inches) in length and were captured in August and September (Shannon, *in litt*. 2001). A single subadult char (222 millimeters; 8.7 inches) was caught at this same site in September of 2002 (J. Shannon, Taylor Associates, Inc., pers. comm. 2002). In May of 2003, a large adult bull trout (582 millimeters; 23 inches) was captured in the lower Duwamish River at Kellogg Island (Shannon, pers. comm. 2003).

It is not known whether bull trout historically occupied habitats in the upper Green River basin, however given their life history it is certainly possible. Various fish sampling efforts in the upper Green River (above Howard Hansen Dam) have not detected bull trout (KCDNR 2000). The City of Tacoma has proposed to construct a trap and haul facility at the Headworks Diversion Dam to allow fish passage to the upper watershed as part of their habitat conservation plan. Although uncertain, it is possible that a bull trout population may become established or reestablished in the upper watershed once this facility is constructed. Establishing a self-sustaining population in the Green River system would help maintain bull trout distribution within the southern portion of the Puget Sound Management Unit. The recovery team currently identifies the upper Green River, above the Headworks Diversion Dam, as a research needs area.

Lower Nisqually River foraging, migration, and overwintering habitat. As bull trout populations recover, the Nisqually River and McAllister Creek estuary and lower Nisqually River will provide significant foraging, migration, and overwintering habitat for bull trout in south Puget Sound. Although it is unknown whether a remnant bull trout population continues to persist in the lower Nisqually River drainage, it is believed that there is a high likelihood that recovered populations of bull trout from the Puyallup and other

Puget Sound Management Unit core areas will use this area in the future. Historically, anadromous bull trout were described entering the Nisqually River as early as the first of June (Suckley and Cooper 1860), which is the typical river entry timing of prespawning bull trout seen today. In addition to this observation, it was noted that larger individuals were generally caught during the summer versus the fall, further suggesting that rivers such as the Nisqually and Duwamish supported anadromous spawning populations of bull trout at that time. Although Suckley and Cooper (1860) described bull trout entering the Nisqually River in “vast numbers” starting in October, there have been only rare observations of bull trout in recent years. A single juvenile was collected during stream sampling in the lower reaches of the Nisqually in the mid-1980's (WDFW 1998). In the late 1990's, a single adult was observed at the Clear Creek Hatchery in mid-September (J. Barr, Nisqually Tribe, pers. comm. 2003). This fish was approximately 508 to 558 millimeters (20 to 22 inches) in size and presumed to be anadromous based on its “bright” coloration.

The Nisqually River originates from glaciers and streams on the south side of Mount Rainier in the National Park and flows westerly to Alder Reservoir created by Alder Dam. Downstream from Alder Dam is LaGrande Dam from which the river flows northerly to south Puget Sound. LaGrande Dam, located at river mile 42.5, limits potential upstream use by anadromous fish including bull trout. A natural barrier may have historically existed near the location of LaGrande Dam, naturally limiting migratory bull trout use. There is currently no evidence of a remnant bull trout population existing upstream of these two dams. The upper Nisqually watershed, upstream of LaGrande Dam, has currently been identified by the recovery team as a research needs area.

The Nisqually River estuary is the only major undeveloped delta in south Puget Sound, offering a variety of intact and restorable foraging habitat for anadromous subadult and adult bull trout. Significant portions of historical estuarine habitat are currently separated from the delta by dikes. The restoration potential of these areas is recognized as providing significant opportunity to improve habitat conditions of the Nisqually River estuary (Wiltermood Associates, Inc. 2000; USFWS 2002). McAllister Creek is a low gradient stream originating at McAllister Springs and flowing 8.8 kilometers (5.5 miles) to enter the Nisqually River delta southwest of the mouth of the Nisqually River. McAllister Creek may also provide potential foraging habitat for bull trout. The estuary largely falls under the ownership of the Nisqually National Wildlife Refuge and the Nisqually Tribe, while much of the lower river falls under tribal and military ownership. The Nisqually River is bordered on the south bank by the Nisqually Tribal Reservation from approximately river mile 3.7 to 10.6. The Fort Lewis Military Reservation borders the Nisqually River on the north bank from river mile 2.4 upstream to approximately river mile 21. Development along the lower river is light with undisturbed riparian[†] habitat in most areas, which has helped maintain largely intact foraging habitat for bull trout.

There are a limited number of tributaries to the Nisqually River below LaGrande Dam with Muck Creek, Murray Creek, Toboton Creek, Tanwax Creek, Powell Creek, Ohop Creek and the Mashel River being the primary streams. Muck Creek is a significant chum salmon spawning stream and the Mashel River is utilized by both Chinook and coho salmon, providing potential habitat for foraging bull trout. Many of the remaining tributaries have only short useable reaches and mainstems with relatively poor salmonid habitat due to impacts from agricultural development. It is unknown whether these tributaries historically provided significant foraging habitat for bull trout.

Marine foraging, migration, and overwintering habitat. Within the Puget Sound Management Unit, anadromous bull trout require access to marine waters, estuaries, and lower reaches of rivers and lakes to forage and overwinter. It is generally believed that some level of mixing or interaction within marine waters occurs among anadromous individuals from the various core areas identified in Puget Sound. Although recent and past studies have documented bull trout from one major Puget Sound river basin moving into the downstream portions of another via marine waters (WDFW *et al.* 1997; Goetz, *in litt*. 2003b), there is currently insufficient information to understand the full extent to which bull trout express this behavior. Although some level of basin to basin movement has been observed, there is currently no information that indicates anadromous bull trout spawn in basins which do not contain their natal stream/watershed. Historically, anadromy could have played a role in establishing this species' distribution within Puget Sound. Anadromy may potentially function as an important means for the natural reestablishment of extirpated populations.

Given that it is currently unclear to what degree this behavior actually influences population structuring within Puget Sound, we have chosen to define all marine and estuarine waters solely as important foraging, migration, and overwintering habitat at this time. These "common" marine habitats cannot be accurately linked with any specific core population(s) until additional information becomes available that can help further refine the migratory patterns of bull trout within core areas. The "marine" foraging, migration, and overwintering habitat currently includes Puget Sound and associated nearshore and estuarine areas. These areas are important for maintaining life history diversity and for providing marine foraging within the management unit.

The current distribution of bull trout within Puget Sound marine waters is not completely known, but has been documented from the Canadian border to at least Commencement Bay to the south (Kraemer 1994; McPhail and Baxter 1996; WDFW 1998; Pacific International Engineering 1999; Ballinger, *in litt*. 2000; KCDNRP 2002). As late as 1978, their marine distribution was still identified as far south as the Nisqually River Delta (Fresh *et al*. 1979). The more recent observation made at the Clear Creek Hatchery would indicate that bull trout still occasionally migrate in marine waters to at least the Nisqually River. It is unknown if individuals from Puget Sound populations migrate as far west as the Kitsap Peninsula and the Strait of Juan de Fuca, or to what extent they may migrate up the coast of British Columbia. One bull trout tagged in the Squamish River in British Columbia was recaptured in the Skagit River (McPhail and Baxter 1996), and another tagged in the Nooksack River was later recovered in the Lower Fraser River (Kraemer, pers. comm. 2003a). It is thought that bull trout primarily use the shallower nearshore waters along the eastern shore of Puget Sound, and occasionally use or cross deeper waters to access nearshore locations along the west side of the sound (*e.g.*, Whidbey Island). Currently few observations of bull trout have been reported in nearshore areas around the small islands of eastern Puget Sound, however anadromous bull trout are presumed to use many of these nearshore areas based on their accessibility and the abundant forage fish populations they support. Although there has been only limited study of their diet in marine waters, bull trout appear to utilize these productive shallow waters to forage on a variety of prey items. Bull trout appear to target juvenile salmonids and small marine fish such as herring, sandlance, and surf smelt, especially keying in on their spawning beaches (Kraemer 1994). Bull trout have also been noted to feed heavily on shiner perch (*Cymatogaster aggregata*) at some locations (Castle, pers. comm. 2003c; Berge, pers. comm. 2003b).

Bull trout use of the marine environment is thought to be similar to that of other species, such as anadromous Dolly Varden and cutthroat trout. Thorpe's (1994) review of salmonid estuarine use found that anadromous Dolly Varden have an affinity to the shoreline. He also found clear evidence of a trophic advantage to estuarine residency (abundant prey). Aitkin (1998) reviewed the estuarine habitat of anadromous salmon, including native char. His literature review found that Dolly Varden pass through estuaries while migrating, like steelhead, and inhabit coastal neritic waters (nearshore marine zone extending to a depth of 200 meters [656 feet], generally covering the continental shelf), like cutthroat trout. In Chignik, Alaska, Dolly Varden in the estuary preyed upon amphipods (81.1 percent), gastropods, and isopods, while sand lance were 1 percent of their diet (Roos 1959). From a sample of 145 Dolly Varden (121 to 490 mm; 4.7 to 19.3 inches), Armstrong (1965) found the principal foods by occurrence to be juvenile pink and chum salmon (21.6 percent), mysids (17.6 percent), amphipods (12.7 percent) and capelin (9.8 percent). Thorpe (1994) reported that Dolly Varden feed heavily on amphiphods, mysids, and various fish.

Bull trout may also use the estuaries and reaches of river systems that are historically or currently unlikely to support spawning populations of bull trout, such as the Samish River and Duwamish River. Bull trout are believed to be foraging on juvenile salmonid downstream migrants or other fish species while occupying these areas, and potentially overwintering there as well. The extent of past and current bull trout use of smaller independent creek drainages that discharge directly into Puget Sound is not well known, with only a few known reported observations. In Bellingham Bay, bull trout were observed in Squalicum Creek in the late 1970's and in lower Whatcom Creek more recently (Currence, pers. comm. 2003a). In 2002, three subadult bull trout approximately 203 to 229 millimeters (8 to 9 inches) in length entered the Maritime Heritage Fish Hatchery pond. These were reported to be the first bull trout observed at the facility in more than a decade, although formerly one to two a year were said to be observed at the facility. In contrast, bull trout from coastal populations on the Olympic Peninsula have recently been documented using a number of small independent creek systems flowing into the Pacific Ocean (USFWS 2004). Even if it is determined that many of the small stream systems in Puget Sound are not commonly occupied by bull trout, these streams still provide an important contribution to the potential forage base for bull trout using adjacent nearshore marine waters or other parts of Puget Sound.

Importance of Identified Core Areas and Foraging, Migration, and Overwintering Habitats in the Puget Sound Management Unit.

The eight identified core areas (summarized in Table 5) all play a critical role in the recovery of bull trout in the Puget Sound Management Unit. Each core area is vital to maintaining the overall distribution of bull trout within the management unit; however, the Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas are particularly critical for maintaining the distribution of the anadromous life history form unique to the Coastal-Puget Sound Distinct Population Segment. The Puyallup core area plays a vital role in maintaining anadromous bull trout distribution in the management unit, because it is the only major watershed in south Puget Sound supporting a population with this life history form. Although the Lower Nisqually River, Lower Green River, and Lake Washington/Lower Cedar River are used by anadromous bull trout, currently no spawning populations have been detected in these systems. These areas, in addition to the Samish River and Puget Sound marine waters, are essential to support the unique migratory behaviors and requirements of anadromous bull trout. When comparing all core areas within the management unit, the Lower Skagit is unique in its geographic size and population abundance. This core area is believed to be central to maintaining anadromous bull trout within the Puget Sound Management Unit.

Table 5. Summary of core area status, Puget Sound Management Unit. Population trend status must be interpreted with caution, since the availability of consistent survey data is limited; the development of a standardized survey protocol to improve the quality of this data set is one of the identified research needs in this plan.

CORE AREA	EST. NUMBER OF LOCAL POPULATIONS IN U.S. (CANADA)	ESTIMATED ADULT ABUNDANCE	LIFE HISTORY FORMS PRESENT	POPULATION TREND	NOTES
Chilliwack[a]	3 (7)	> 1,000[c]	fluvial, adfluvial; possibly anadromous and resident	unknown	no long-term monitoring data available
Nooksack	10	< 1,000	anadromous, fluvial; possibly resident	unknown	no long-term monitoring data available; population numbers generally low
Lower Skagit	19	> 1,000[d]	anadromous, fluvial, adfluvial, resident	stable to increasing	based on limited monitoring data
Upper Skagit[a]	7[b] (6)	> 1,000[c]	fluvial, adfluvial; possibly resident	unknown	populations in Canada “presumed healthy”
Stillaguamish	4	< 1,000	anadramous, fluvial, resident	unknown	limited data; population numbers low

Table 5 (continued). Summary of core area status, Puget Sound Management Unit. Population trend status must be interpreted with caution, since the availability of consistent survey data is limited; the development of a standardized survey protocol to improve the quality of this data set is one of the identified research needs in this plan.

CORE AREA	EST. NUMBER OF LOCAL POPULATIONS IN U.S. (CANADA)	ESTIMATED ADULT ABUNDANCE	LIFE HISTORY FORMS PRESENT	POPULATION TREND	NOTES
Snohomish-Skykomish	3[b]	500 - 1,000	anadramous, fluvial, resident	increasing	based on limited monitoring data
Chester Morse Lake	4	500 - 1,000	adfluvial; possibly fluvial or resident	stable to increasing	based on limited monitoring data
Puyallup	5	< 1,000	anadromous, fluvial, resident	unknown	few monitoring data available; population numbers generally low

[a] these core areas share local populations with Canada (number of local populations in Canada shown in parentheses)

[b] does not include resident populations

[c] estimates of adult abundance for these core areas include the local populations in Canada, since those populations are functionally a part of the core area for the purpose of evaluating the risk of genetic drift

[d] adult abundance of this core area is estimated to be several thousand individuals, making it likely the largest population of bull trout in Washington

Part II: Puget Sound Management Unit Distribution and Abundance

REASONS FOR DECLINE

Bull trout distribution, abundance, and habitat quality have declined rangewide (see 63 FR 31647, 63 FR 31647, 64 FR 58910, and references therein). Within the coterminous United States, these declines have resulted from the combined effects of habitat degradation and fragmentation, the blockage of migratory corridors, poor water quality, angler harvest and associated hooking mortality[†] , poaching, entrainment into diversion channels and dams, and introduced nonnative species. Some of the historical activities, especially water diversions, hydropower development, forestry, agriculture, and development within the core areas, may have significantly reduced important anadromous populations. Some of these early land and water developments still act to limit bull trout production in core areas. Threats from current activities are also present in all core areas of the Puget Sound Management Unit. Land and water management activities that depress bull trout populations and degrade habitat in this management unit include some aspects of operation and maintenance of dams and other diversion structures, forest management practices, agriculture practices, road construction and maintenance, and residential development and urbanization. It should be noted that many of the reasons for decline, which primarily focus on their direct impacts to bull trout and their habitat, have also indirectly impacted bull trout by affecting their prey species (*e.g.*, salmon and forage fish) and their habitats within the management unit.

These reasons for decline will be presented according to the five factors identified under the Endangered Species Act that may have negative impacts on a species, potentially leading to its decline. Those five factors are (from section 4(a) of the Act):

- (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
- (B) overutilization for commercial, recreational, scientific, or educational purposes;
- (C) disease or predation;
- (D) the inadequacy of existing regulatory mechanisms;
- (E) other natural or manmade factors affecting its continued existence.

<u>Dams (Factor A)</u>

Overview. Restoring and maintaining connectivity between remaining populations of bull trout is important for the persistence of the species (Rieman and McIntyre 1993). Migration and spawning between populations increases genetic variability and strengthens population viability (Rieman and McIntyre 1993). Barriers caused by human activities limit population interactions and may eliminate life history forms of bull trout. Bull trout that migrate downstream of dams without fish passage are unable to contribute to the bull trout population upstream. In many systems controlled by dams, this loss can be significant. Additionally, dams and diversions significantly affect downstream habitats by altering sediment transport, woody debris distribution, and natural flow and temperature regimes. Dams and diversions have reduced the level of watershed connectivity in several core areas in the Puget Sound Management Unit. In many cases, dams in the management unit have likely been constructed at or near historical natural barriers to anadromous fish passage. In these cases, impacts to bull trout habitats downstream are of greater threat than potential impacts to population connectivity. Population connectivity remains a concern even where trap and haul facilities have been implemented to address passage issues, given bull trout's complex migratory patterns and the difficulty in fully replicating volitional passage (*i.e.*, allowing fish to decide when to migrate) with these types of facilities. There are a number of proposals to develop new hydropower facilities in the Puget Sound Management Unit (Nooksack, Lower Skagit, and Snohomish-Skykomish core areas) which have the potential to further fragment or degrade bull trout habitats (FERC 1998; FERC 2002a; FERC 2002b). Many negotiated instream flows for these projects have been based on resident cutthroat or rainbow trout flow requirements, and may not meet the needs of bull trout which have different life history strategies (Bodurtha, *in litt*. 1995).

Nooksack core area. The City of Bellingham Diversion Dam on the Middle Fork Nooksack River has separated a once connected population of bull trout into two separate groups, one primarily isolated upstream of the facility and one containing anadromous bull trout below. The Upper Middle Fork Nooksack River local population includes resident and fluvial bull trout which use the mainstem river and tributaries above the City of Bellingham Diversion Dam.

Some question exists as to whether a few migratory bull trout may still occasionally negotiate the diversion dam to spawn upstream of the facility. Prior to the construction of the diversion dam it is believed that the reach upstream of the facility harbored both fluvial and anadromous bull trout. While spawning has not been observed downstream of the dam, it is thought to occur in or slightly downstream of the canyon area, since staging adults have been observed at this location (Kraemer, pers. comm. 2002). Passage through the gorge is considered possible at discharges below 1,000 to 1,500 cubic feet per second, based on limited numeric modeling of discharges and velocity refuges continuing to exist behind large boulders (Zapel, pers. comm. 2003). While the diversion dam does not have a reservoir behind it, nor interrupts routing of sediment or large woody debris, it blocks most upstream migration. This likely forces some bull trout to spawn in suboptimal areas such as the confined gorge where redd scour may occur. Spawning and early rearing habitat in the Upper Middle Fork Nooksack River local population is generally believed to be in good and improving condition, since 90 percent of the area is managed under U.S. Forest Service Late Successional Reserves or Washington Department of Natural Resource's Habitat Conservation Plan (Currence 2000). Passage past this facility would provide access to at least 15 miles of additional spawning and/or rearing habitat expected to be used by the anadromous life history form. Restoring passage would also restore connectivity for the full expression of migratory life histories, increase the potential forage base by reestablishing anadromous salmon spawning distribution, and improve genetic exchange within the core area. While the diversion dam is screened, these screens are not to current standards, and may entrain outmigrating juveniles. Additionally, 67 cubic feet per second is diverted from the river when in operation, and the current facility does not have the ability to ramp[†]. This may adversely affect bull trout in reaches downstream. In addition to ramping, minimum instream flows need to be evaluated and revised as necessary to assure that all lifestages of bull trout are adequately protected.

At Excelsior/Nooksack Falls (North Fork Nooksack River), there is an outdated hydropower facility that was damaged in a fire in the 1990's and abandoned, but this was recently restarted without appreciable upgrades that are needed to ensure protection of bull trout. The intake to this facility is located upstream of Nooksack Falls, and the powerhouse and tailrace are located on the

North Fork Nooksack River downstream of Wells Creek. Several issues need to be addressed to avoid adversely impacting bull trout. One issue is that the facility requires tailrace protection to exclude fish that are likely to be attracted to it. Pink salmon were observed congregating in the flow of the tailrace outfall when the facility was formerly operating (D. Schuett-Hames, Cooperative Monitoring and Evaluation Committee, pers. comm. 2003). Additionally, minimum instream flows should be revised as necessary to assure that all lifestages of bull trout are adequately protected. As described in the core area description, this is an important adult staging, spawning and early rearing area. The facility must be modified as needed to accommodate ramping, and operated with appropriate ramping rates to avoid impacting bull trout downstream of the facility. If bull trout exist upstream of Nooksack Falls, the intakes would need to be appropriately screened to avoid entrainment of bull trout from this isolated population.

Other small hydroelectric facilities located in spawning, rearing or foraging habitat should be evaluated and their operations adjusted and/or facilities upgraded as necessary to avoid impacts to bull trout.

Lower Skagit core area. The City of Seattle hydroelectric complex on the upper Skagit River (Gorge, Diablo, and Ross Dams) is thought to have been placed at the approximate site of a historical migration barrier(s). Genetic exchange between the upper river populations and the lower river may have been primarily one-way (downstream). Prior to construction of the dams, it is possible that on rare occasions fish in the Lower Skagit core area gained access beyond the barriers to the Upper Skagit core area, but it is not known for certain. The presence of char and rainbow trout in the upper Skagit drainage supports the supposition that these fish did gain access at some point in time. It is believed that historically bull trout could migrate upstream to at least the area near Diablo Dam. Prior to construction of Seattle City Light’s three dams, the Skagit River ran through a narrow and steep canyon for 22.5 kilometers (14 miles) from the current location of Ross Dam to the town of Newhalem (river mile 94). Biological surveys conducted by University of Washington biologists prior to the construction of Seattle City Light's dams indicated that native char were "very abundant" in the 1.6-kilometer (1-mile) section of the Skagit River immediately upstream of the town of Newhalem (Smith and Anderson 1921). These early biological surveys (Smith and Anderson 1921) and interviews with local residents (Envirosphere 1988) indicate that salmon were not able to migrate any farther than 1.6 kilometers (1 mile) upstream of Newhalem, although small numbers of steelhead trout were able to migrate as far upstream as Stetattle Creek (river mile 100) and Reflector Bar (river mile 100.5). Since steelhead trout were able to migrate this far upstream, it is possible that bull trout in the lower Skagit River could also have migrated upstream as far as Reflector Bar prior to the construction of Gorge Dam. Upstream of this point, the Skagit River flows through Diablo Canyon, a bedrock gap where the river narrows to about 2.4 meters (8 feet) in width. This narrow gap, likely the upstream limit of steelhead and bull trout migration, is located just downstream of the current location of Diablo Dam (river mile 100).

Anadromous access to the current location of Gorge Dam has been blocked to this area since 1919, after the construction of the original woodcrib dam, and the two successive replacements at the current Gorge Dam site (Williams *et al.* 1975). Bull trout in Gorge Lake, the reservoir formed by the current high dam built in 1961, are currently isolated from other populations within the Skagit River system, except for individuals from Diablo Lake passing downstream through Diablo Dam, built in 1930. There is currently a limited amount of available potential spawning habitat in the Gorge Lake system, the lower 2.7 kilometers (1.7 miles) of Steattle Creek and that portion of the Skagit River mainstem from the reservoir up to Diablo Dam (less than 1.6 kilometers; 1 mile) (WDFW 1998). The best areas for bull trout spawning is in a free-flowing section of the river located immediately upstream from Gorge Lake near the mouth of Stetattle Creek (Connor, pers. comm. 2003c). Changes in the flow regime[†] of the mainstem Skagit River below Diablo Dam and above Gorge Lake should be evaluated and considered to enhance available spawning habitat. Potential changes to the flow regime in this reach may be limited, because the current flow regime must adhere to the conditions of the Skagit Hydroelectric Project Fisheries Settlement Agreement. This agreement was signed by Seattle City Light, the Federal and State fishery agencies, and Tribes in 1991 to protect anadromous and resident fish in the 38.6-kilometer (24-mile) reach of the Skagit River downstream of Newhalem. Based on the perceived connectivity structure that existed within this system prior to construction of the three upper Skagit River dams, passage between the Lower Skagit River and Gorge Lake should be evaluated and considered. An assessment of the genetic uniqueness of individuals residing within this system will help determine how critical it is to improve connectivity with this functionally isolated group of bull trout, and whether it should be identified as a separate core area in the management unit.

In addition, the three upper Skagit River dams have prevented the transport of large wood to the Lower Skagit core area. This, in conjunction with past wood removal efforts, has significantly contributed to the reduction of historical habitat complexity in the Lower Skagit River mainstem and estuary.

Two Puget Sound Energy hydroelectric dams, Lower and Upper Baker Dams, have greatly limited fish movement in the Baker River system since 1927 and 1955, respectively (Williams *et al.* 1975; WDFW 1998). Two large reservoirs have been created by the lower and upper dams, Lake Shannon and Baker Lake, respectively. Lake Shannon has inundated 14.4 kilometers (9 miles) of riverine habitat and the lower reaches of tributaries which potentially provided historical spawning habitat. The original Baker Lake was greatly enlarged after construction of the upper dam, inundating potential spawning habitat in tributaries discharging into the lake. Early biological surveys conducted by University of Washington researchers prior to the construction of the upper dam reported that there were large numbers of native char, with fish commonly 11.0 to 17.6 kilograms (5 to 8 pounds) in size. The abundance of native char was attributed to an excellent food supply, especially juvenile sockeye salmon. These migratory native char (presumably bull trout) were observed to spawn in the upper Baker River immediately upstream of the lake (Smith and Anderson 1921). The dams on the Baker River have altered the historical connectivity with the rest of the lower Skagit River system, however, available information seems to indicate that there is currently a reluctance for bull trout to migrate from the Baker Lake complex. This may be the result of the abundant forage base that exists in the lake (juvenile sockeye and kokanee) reducing or negating the need to migrate to marine forage areas. Small numbers of bull trout are collected at the adult trap-and-haul facility at the Lower Baker Dam and transported upstream of the dams to Baker Lake each year. Connectivity is dependent on this trap-and-haul facility and the Baker and Shannon Lakes smolt traps. It is unknown to what extent bull trout migrated in and out of this system prior to the damming of the Baker River and the enlargement of Baker Lake. Improved passage past these two facilities would restore the opportunity for the full expression of migratory life histories and improve genetic exchange within the core area. Operations at the Lower Baker Dam continue to impact downstream salmonid habitats in the lower Baker and Skagit Rivers as a result of rapid changes in flow releases and the change of the lower Baker River from a free flowing river to a still water system (WSCC 2003).

Upper Skagit core area. Ross Lake is a 38-kilometer (24-mile) long reservoir impounded by Ross Dam which was completed in 1949 and is operated by Seattle City Light (Williams *et al.* 1975). This reservoir provides the foraging, overwintering, and migration habitat for the adfluvial bull trout population in this core area. Ross Lake is typically full from late June through mid-September, and then partially drawn down during the winter for flood control purposes and for maintaining flows downstream in the lower Skagit River for salmon and steelhead. Prior to construction of Ross Dam, many of the tributaries currently used by bull trout were inaccessible due to steep cascades; however, reservoir elevations have since allowed access. The formation of the reservoir has eliminated mainstem and lower tributary habitats that were likely used for spawning and rearing prior to inundation. Ross Dam is a passage barrier to the upstream and downstream migration of native char between Ross Lake and Diablo Lake, however the level of bull trout emigration from Ross Lake to Diablo Lake has not been determined. Native char were reported to be very abundant in this area before inundation by the reservoir, particularly in the lower reaches of Ruby Creek (Smith and Anderson 1921). Diablo Lake may act as a sink to the segment of the population inhabiting Ross Lake, given that there is no upstream passage between these two lakes and the limited spawning habitat in the Diablo Lake system. Studies are presently being initiated to identify whether there are genetic differences between bull trout or Dolly Varden in Ross Lake and Diablo Lake.

Chester Morse Lake core area. There is no direct evidence to suggest that this core population has declined from its historical level. However, several conditions related to the water supply and hydroelectric generating systems exist that may modify and/or restrict free movement of an unknown portion of the bull trout population both within the full extent of the reservoir system as it now exists, and/or downstream to lower reaches of the Cedar River.

The modification of the natural outlet channel of Cedar Lake (currently Chester Morse Lake) by construction of the historical wooden Crib Dam (Overflow Dike) and subsequent construction of the Masonry Dam 2.3 kilometers (1.4 miles) downstream has created an additional body of open water. Masonry Pool now exists between the two dams and is contiguous with Chester Morse Lake. Although fish can pass freely between the two bodies of water when reservoir levels are relatively high and above the current spillway height of the Overflow Dike (more than 472 meters; 1,550 feet surface elevation), annual fluctuations in the reservoir in conjunction with demands for water supply and required flow (*e.g.*, fish flows) in the lower Cedar River necessitate that reservoir levels drop below the Overflow Dike spillway. This effectively ‘disconnects’ free surface flow between the Chester Morse Lake and Masonry Pool. During these periods, water is continually released from Chester Morse Lake through a control gate at the base of the Overflow Dike. Fish may be able to pass downstream through this gate, however, they may incur some unknown degree of injury, or be killed, depending upon flow velocities and/or in what manner they contact the flow dissipation structure at the flow outlet from the control gate. The level of entrainment and extent of injury to bull trout passing through the Overflow Dike control gate structure from Chester Morse Lake to Masonry Pool is unknown (Knutzen 1997).

Any bull trout present in Masonry Pool during periods when the lake and pool are ‘disconnected’ (typically from late summer to the period of spring refill) are presumably unable to migrate upstream through the Overflow Dike (*i.e.*, velocity barrier) and subsequently into Chester Morse Lake. The effect(s) on the core population of this apparent restriction of movement is unclear, but the most significant may be that some potential bull trout spawners may be prevented from migrating upstream. No bull trout spawning activity has been observed to date in exposed stream flow reaches of Masonry Pool or in the only tributary to the pool, Lost Creek (which typically exhibits subsurface flow conditions during the bull trout spawning season) (Paige, *in litt*. 2003).

Entrainment of downstream migrating bull trout at the intake tunnel/penstock[†] structures (located at the Masonry Dam) for the hydroelectric facility at Cedar Falls may potentially occur because the intakes are currently unscreened. The number of bull trout in Masonry Pool is very low relative to the number found in Chester Morse Lake; however, Knutzen (1997) estimated that the loss of bull trout from entrainment may be about 200 fish per year, with the estimated number of fish lost ranging from 10 to several hundred individuals. It has not been definitively determined whether all individuals that may be entrained die. At certain levels of generation (turbine speed), it is possible for even relatively large fish to physically pass through the turbines. The key question is whether or not some fish can survive the pressures experienced in the penstocks and as they pass through the turbine generators. Any bull trout entrained at the Masonry Dam, or passing over the dam during periods of spilling, are lost to the core area because no upstream interchange can occur. Both means of fish movement out of the reservoir complex represent an irretrievable loss of individuals from the local population to a river reach where, at least at this time, there appears to be little chance for either successful establishment or maintenance of a viable bull trout population. Mortality resulting from entrainment may potentially explain the limited number of observations of bull trout in the Cedar River between Cedar Falls and Landsburg; however, there may be several other contributing factors of similar or greater potential significance (*e.g.*, temperature, habitat, interspecific competition[†]) that might explain the paucity of bull trout observations in the Cedar Falls/Landsburg reach.

Most bull trout in this core area spawn in lower reaches of both primary and secondary tributaries of Chester Morse Lake within a maximum distance of approximately 2.9 kilometers (1.8 miles) of the Cedar River and much closer for other streams (refer to core area discussion). Access to spawning reaches may be restricted during periods of unusually low reservoir drawdown because of potential physical barriers to passage at the ‘lip’ of delta fans, as in the case of the Cedar and Rex Rivers (WDFW 1998; City of Seattle 2000b), and by subsurface flow conditions at the confluences of secondary lake tributaries (*e.g.*, Rack and

Shotgun Creeks) (Paige, *in litt*. 2003). However, during the 2002 spawning season when both stream flow and reservoir levels were either at or approaching record low levels, bull trout were able to successfully access traditional spawning reaches in the Cedar and Rex Rivers and bull trout redd counts were the highest recorded in the Chester Morse Lake core area since counts began in the early 1990's. Bull trout were also able to take advantage of very brief period(s) of stream flow freshets to gain access and spawn in at least one of the secondary tributaries to the lake (Rack Creek) that typically supports a relatively low level of bull trout spawning activity (Paige, *in litt*. 2003).

These recent observations indicate that even under such extreme environmental and operational conditions as existed within the reservoir during fall 2002, bull trout in the Chester Morse Lake core area are not prevented, and presumably not restricted, from spawning. Stream flow and reservoir drawdown levels more extreme than those experienced in fall 2002 are predicted to be especially rare events within the watershed and adverse impacts to the bull trout population from such conditions are not expected to occur on any regular basis (City of Seattle 2000b). Also, it is even less probable that conditions sufficient to completely prevent all bull trout from accessing spawning reaches for the entire spawning period would occur during any year.

Given that the bull trout local populations have evolved within the system and probably have historically experienced complete or near complete loss of an entire age class because of peak flow, flood flows, or even low flow conditions in some instances, it could be assumed that the local populations in this core area would persist and not be critically jeopardized if spawning were restricted by the combination of environmental and operational constraints at a frequency not unlike that created by naturally occurring events. If future reservoir drawdown conditions more severe than those existing in 2002 do occur, and actually prevent bull trout from accessing traditional spawning reaches, the City has committed to the development and implementation of a ‘passage assistance plan’ under the habitat conservation plan (City of Seattle 2000b).

Because most bull trout in this core area spawn in lower reaches of the Cedar and Rex Rivers upstream of Chester Morse Lake within a distance of approximately 2.9 kilometers (1.8 miles) in the Cedar and 1.1 kilometers (0.7 mile) in the Rex, and portions of these spawning reaches are within the potential inundation zone of the reservoir during the period of spring refill, eggs and/or alevins remaining in redds when rising water levels reach specific sections of the lower rivers may be susceptible to potential adverse impacts resulting from inundation (City of Seattle 2000b). The maximum number of redds that could be inundated annually at the maximum level of reservoir refill (elevation 477 meters; 1,564 feet) is substantial, especially in the Rex River (nearly 100 percent). In actuality however, the number/percent of redds that are inundated at some point during the extended refill period is significantly less. The operational timing of reservoir refill relative to egg incubation periods and fry emergence dates at specific redd locations within the reaches substantially reduces the number of redds at risk of potential adverse effects from inundation. Presumably, the degree of any realized adverse effects to bull trout eggs and/or alevins remaining in redds at the time of inundation decreases substantially at later stages of incubation. The specific combination of the extent of inundation (*i.e.*, depth), duration of inundation, and the amount of fine sediment deposited may also have bearing on the potential adverse impacts of inundation and will be widely variable from year to year. Because the actual impacts to bull trout eggs/alevins resulting from inundation have not yet been definitively determined, and the overall effect on spawning success is not known, the potential effect of inundation on the bull trout population(s) in the Chester Morse Lake core area remains a concern. These concerns are currently being monitored and assessed under elements of the Cedar River Watershed Habitat Conservation Plan (City of Seattle 2000b).

Puyallup core area. Connectivity of the upper Puyallup and Mowich Rivers with other local populations and foraging, migration, and overwintering habitats has been limited by the Puget Sound Energy's Electron Diversion Dam, allowing only downstream connectivity. Electron Dam had effectively isolated bull trout in the upper Puyallup and Mowich Rivers from the rest of the basin for nearly 100 years (WSCC 1999b). Recently, a new fishway was constructed to improve upstream fish passage and has been fully operational since October 13, 2000. This facility is expected to significantly improve connectivity and genetic interaction with other local populations within the core area. However, bull trout continue to be threatened by entrainment into the facility's unscreened power canal (Ging, pers. comm. 2003). Currently, bull trout that enter the power canal are unable to migrate back out due to high water velocities. Bull trout trapped in the canal can be removed by the fish collection facility within the canal; however, recent fish rescue efforts associated with several canal drawdowns indicate that bull trout are able to avoid capture by the current fish collection facility (Feldmann, *in litt*. 2002; Ging, pers. comm. 2002a). Although minimum instream flows have improved (60 cubic feet per second between November 16 through July 14, and 80 cubic feet per second between July 15 through November 15) as a result of the 1997 Resource Enhancement Agreement between Puget Sound Energy and the Puyallup Tribe (WSCC 1999b), the diversion of water still significantly affects habitat availability in the 16.9 kilometer (10.5 mile) bypass reach.

Mud Mountain Dam, a flood control structure in the lower White River at river mile 29.6, and Puget Sound Energy's Buckley Diversion Dam at river mile 24.2, form barriers to natural migration. Completed in 1911, the Buckley Diversion diverts water from the mainstem White River into the artificial lake, Lake Tapps, which provides storage water for power generation at the Dieringer Powerhouse. These two structures have historically been a problem for both downstream and upstream fish passage. Historically, significant numbers of salmon and bull trout have been lost when the timing of downstream migration coincides with the diversion of the White River into Lake Tapps (Heg *et al.* 1953; WDFW 1998). The Washington Department of Fisheries operated a downstream migrant trap in 1953, located on the bypass leading from the screens to the White River. Downstream bull trout migration, corrected for fish using the main channel, was estimated to be 693 bull trout between May and July of that year (Heg *et al.* 1953). However, new fish screens placed in 1996 have improved downstream passage. Upstream passage of bull trout and anadromous salmon past these two facilities has been achieved using a trap and haul facility located at the Buckley Diversion Dam, and has operated since 1941 (Heg *et al.* 1953). However, trapping efforts prior to the late 1980's were generally limited to periods during anadromous salmon runs, and it is unknown whether bull trout were consistently passed upstream. Currently, the trap and haul facility is operated year round and adult-sized fish entering the trap are captured and transported upstream above Mud Mountain Dam. The trap and haul is currently not designed to collect juvenile or small subadult upstream migrants (individuals typically less than 350 millimeters [13.8 inches] in length) (Hunter, *in litt*. 2001). The current trap design has resulted in some bull trout mortality (Ging, pers. comm. 2002b). When flows overtop the Buckley Diversion Dam by more than 0.3 meter (1 foot), the flashboard sections are designed to fail to prevent further damage to the structure. Until the flashboard sections are replaced, upstream migrants can pass into the 8-kilometer (5-mile) long reach between Mud Mountain Dam and the Buckley Diversion. These individuals are essentially precluded from further upstream migration until they drop back below Buckley Diversion Dam and enter the trap and haul facility.

Storage of peak flows behind Mud Mountain Dam results in a disruption of sediment routing and ultimate delivery to downstream reaches. This has in turn resulted in prolonged high turbidity and increased concentrations of fine sediment in the substrate. The Buckley Diversion has significantly reduced flows in the 33.8-kilometer (21-mile) bypass reach of the White River, which continues to impact habitat conditions for bull trout in this reach (WDFW 1998). Recent operational modifications of the diversion system have increased base flows in the bypass reach, thereby increasing rearing habitat quantity and quality. Water discharged from the Dieringer powerhouse is returned to the White River at river mile 3.5 via the tailrace outlet canal. This discharge has and continues to vary widely on a daily basis. This discharge has been higher in temperature and lower in dissolved oxygen levels than the mainstem White River during some years, likely impacting available foraging, migration, and overwintering habitat from the point of the outfall to the confluence with the Puyallup River. During other years, colder water has been discharged at the Dieringer powerhouse, which has raised concern over false attraction problems with the tailrace outlet canal, and associated injury or migration delays to migratory salmonids (WSCC 1999b).

While not a dam, the City of Tacoma’s water Pipeline Number 1 crossing on the White River was identified as an impediment to the upstream migration of anadromous salmonids (WSCC 1999b). Although a fish ladder had been installed to facilitate upstream passage, injuries to anadromous salmonids were noted. In 2003, the pipeline was replaced with a new pipeline section that was constructed below the grade of the river bed, so upstream fish passage has now been fully restored.

Lake Washington foraging, migration, and overwintering habitat. The Hiram H. Chittenden (Ballard) Lock system may affect bull trout migration to and from the Lake Washington system. Completed in 1916, the ship canal and lock system changed the outlet of Lake Washington from the southern end to the northern end of the lake, discharging directly into saltwater at Salmon Bay. Impacts to juvenile salmonid outmigrants have been detected in the past, but recent improvements to the facility and its operation have significantly reduced these impacts. A fish ladder is present at this facility, although fish may also be passed through the locks. The effect of the facility on bull trout movements is currently unknown but should be further evaluated, due to the bull trout's unique migratory movements as subadults and adults.

Lower Green River foraging, migration, and overwintering habitat. The City of Tacoma's Headworks diversion dam has been a barrier to upstream migration of anadromous salmonids since 1912, and Howard Hanson Dam has been a barrier to upstream migration since 1961. Since there is little historical information regarding the past distribution of bull trout within the Green River basin, it is not known how much these facilities contributed to the decline of bull trout use within this system. If migratory bull trout historically used most of the accessible areas of the upper Green River, these facilities would have prevented access to the upper watershed for over 80 years. These facilities have also reduced the available spawning habitat for anadromous salmon, which were likely an important prey species for bull trout in this system. Fish passage has recently been planned for these two facilities (Tacoma Public Utilities 2001; Pozarycki, *in litt*. 2004).

Nisqually River foraging, migration, and overwintering habitat. The Yelm Hydroelectric Project consists of a diversion dam located at river mile 26.2, which diverts water through a canal to a powerhouse located at river mile 12.7. It is unknown to what degree this facility contributed to the decline of bull trout use within this system, but we do know the initial diversion structure built in 1929 was likely a barrier to fish passage until modified after several years of operation.

A standard fish ladder did not replace the inadequate, primitive ladder until 1955. Between 1930 and 1955, the diversion canal to the powerhouse was unscreened allowing entrainment of juvenile salmonids, and between 1955 and 1968 the project effectively diverted all water during periods of low flow from the mainstem Nisqually River to the canal and through the turbines (WSCC 1999c).

For nearly 30 years, the Nisqually Hydroelectric Project at LaGrande was operated for peak power, creating rapid changes in downstream flows. This was especially adverse during the summer and fall low flow months, and is attributed with driving Nisqually spring Chinook salmon to the point of extinction by the early 1950's (NCRT 2001). If bull trout utilized this area for spawning in the past, they would have likely been similarly affected during this time period. This project has also interrupted the recruitment of large woody debris and sediment to river reaches below LaGrande Dam (WSCC 1999c).

Significant improvements in Nisqually River base flows, both upstream and downstream from the Yelm diversion, have been in effect since 1993 as a result of a special Federal Energy Regulatory Commission Proceeding to address this issue. In addition, Tacoma Public Utilities has implemented a number of measures (limits on project ramping, gravel augmentation, riparian corridor acquisition) to improve and protect habitat to meet the requirements of its operating license, issued in 1997, for the Nisqually Hydroelectric Project.

Forest Management Practices (Factor A)

Overview. Forestry activities that adversely affect bull trout and their habitat are primarily timber extraction and road construction, especially where these activities involve riparian areas. Such practices can impact stream habitat by altering recruitment of large woody debris, erosion and sedimentation rates, snowmelt timing, runoff patterns, the magnitude of peak and low flows, water temperature, and annual water yield[†] (Cacek 1989; Furniss *et al.* 1991; Murphy 1995; Spence *et al.* 1996; Spencer and Schelske 1998; Swanson *et al.* 1998). Other impacts of timber harvesting may include decreased slope stability (Chamberlin *et al.* 1991; Murphy 1995). Additional adverse effects may have resulted from the use of various pesticides on forest lands (Norris *et al.* 1991).

The Puget Sound region has a long history of timber harvest, beginning in the mid 1800's (Murphy 1995). Harvest in this region began in the Puget Sound lowlands and has progressed higher up into watersheds over time. Most of the lowlands harvested initially for timber were subsequently cleared for agriculture and development. The mainstem reaches of all core areas discharging into Puget Sound have been impacted by past timber harvest. Past forest management practices have left this region with a legacy effects[†] on aquatic habitats, and stream systems continue to recover from these impacts even today. Riparian and stream clearing and the construction of splash dams[†] to facilitate water transport of logs was common practice in western Washington streams (Sedell *et al.* 1991). Repeated splash damming resulted in major long-term damage to fish habitat as the practice caused severe scouring of stream channels, often down to bedrock (Murphy 1995). In tributaries too small for splash dams, trees were typically yarded downstream, degrading stream channels and banks in the process. Splash damming also resulted in estuarine impacts. For example, the Samish River historically had so many forks and sloughs across the delta that no channel had sufficient flow to float logs downstream (Willis 1975). In the 1880's loggers cleared a single channel and blocked off the remaining channels and sloughs to enable logs to be transported to Samish Bay when minor floods were created by opening up a series of wooden splash dams in the upper river (Willis 1973, 1975). Railroad systems were also constructed in many watersheds for transporting timber to mills. Although these forest management practices were improved somewhat by the 1950's, clearcutting to the streambank remained a common practice until the 1980's. Early truck roads were often constructed using techniques which were standard for the day, but resulted in substantial mass wasting. Downstream transport of forest products occurred in larger rivers including the Skagit and Nooksack, and channels had to be sufficiently cleared of hindrances including logjams in order to accomplish this. In the 1970's, forest practice rules began to require the removal of logging debris from streams after timber harvest (Murphy 1995); however, this resulted in complete clearing of large woody debris from many streams. Until recently, State forest practices allowed timber harvest to occur within 7.6 meters (25 feet) of salmonid bearing streams. It is now acknowledged that these minimum widths were often insufficient to fully protect riparian ecosystems (USDI *et al.* 1996).

Large networks of forest haul roads, skid trails/roads, and yarding corridors now exist in many Puget Sound watersheds. Many existing roads were built with techniques that are now considered obsolete. The road network is so large that much of it can not be maintained to current regulatory standards. Much of this road network crosses or parallels stream channels, leaving a legacy of problems such as chronic bank erosion, debris flows, fish passage barriers, chronic delivery of fine sediments, and slope failures. Rashin *et al.*(1999) found that best management practices used even in new road construction were generally ineffective or only partially effective at preventing chronic sediment delivery to streams when the activity occurred near streams. In the Columbia Basin, a recent assessment revealed that increasing road densities and their related effects are associated with declines in the status of four non-anadromous salmonid species (bull trout, Yellowstone cutthroat trout [*Oncorhynchus clarki bouvieri*], westslope cutthroat trout, and redband trout [*O. mykiss gibssi*]) (Quigley and Arbelbide 1997). It was found that bull trout were less likely to use highly roaded basins for spawning and rearing, and if present they were less likely to be at strong population levels (Quigley and Arbelbide 1997). Quigley *et al.* (1996) demonstrated that where average road densities were between 0.4 and 1.0 kilometers per square kilometer (0.7 and 1.7 miles per square mile) on National Forest lands, the proportion of subwatersheds[†] supporting “strong” populations of key salmonids dropped substantially, declining even further with higher road densities. The proportion was even lower for these road densities when land ownership was combined. Although this assessment was conducted east of the Cascades, effects from high road densities may be worse in western Washington. Higher precipitation west of the Cascades increases the frequency of surface erosion and mass wasting (USDI *et al.* 1996).

Recreational activities (camping, trail use, off-road vehicle use) in forested areas have often caused significant localized impacts. These are typically associated with riparian removal and degradation, sedimentation, and degradation of streambanks and channels. However, some of these areas have facilitated access to bull trout staging and spawning areas, and have resulted in increased illegal harvest.

Chilliwack core area. The majority of timber harvest within the Chilliwack River drainage has occurred within British Columbia. Significant timber harvest has occurred throughout the drainage within British Columbia and continues today. In the past, significant logging has occurred in all eight currently identified local populations completely or partially within British Columbia (Airplane, Borden, Centre, Depot, Foley, Paleface, Nesakwatch, and Silesia Creeks) (M.A. Whelen and Associates Ltd. and TSSHRC 1996). Although Chilliwack Lake is now entirely within the Chilliwack Lake Provincial Park, Paleface and Depot Creeks are almost entirely outside of the Provincial Park boundary with the exception of their lower reaches. The upper reaches of Depot Creek and other parts of the Chilliwack River system in Washington State are within North Cascades National Park, and therefore have been free of timber harvest impacts. The kokanee population in Chilliwack Lake is said to likely remain abundant and stable, given the Provincial Park status around the lake coupled with the view that Paleface and Depot Creeks have recently stabilized following extensive logging within these systems (Nelson and Caverhill 1999). Whether bull trout populations using these two creeks are stable is unknown, but given the much longer period of stream rearing by juvenile bull trout compared to that of juvenile kokanee, they likely have been and might continue to be more impacted by the logging that has occurred within these systems. Reaches of Silesia Creek within British Columbia currently have very little large woody debris, which has been attributed to increased riparian timber harvest (M.A. Whelen and Associates Ltd. and TSSHRC 1996).

Nooksack core area. Timber harvest and associated road building have substantially impacted spawning and rearing habitat in the Nooksack core area. Much of the upper Nooksack watershed is naturally prone to mass wasting due to steep topography, inherently unstable geology, and high precipitation, but forest practices have substantially increased the magnitude and frequency of mass wasting events. Natural slope instability combined with the timber management history have combined to disproportionately impact this core area. The Washington State Conservation Commission (WSCC 2002a) summarized a number of landslide inventories for the three river forks, and reports 632 mass wasting events in the North Fork (36 percent associated with roads, 28 percent associated with clearcuts), 480 mass wasting events in the Middle Fork (36 percent associated with roads, 32 percent associated with clearcuts), and 1,216 mass wasting events in the South Fork (37 percent associated with clearcuts, 32 percent associated with roads). The highest landslide densities in the North Fork are in Cornell, Racehorse, Gallop, Boulder, Coal, Canyon, and Glacier Creek drainages respectively (WSCC 2002a). Porter, Canyon Lake and Clearwater Creek drainages have the highest landslide densities respectively in the Middle Fork basin (WSCC 2002a). Landslide densities are very high in the small drainages of the lower 21 kilometers (13 miles) of Skookum Creek and in the upper South Fork including Wanlick Creek, and densities are moderate in the Hutchinson Creek drainage (WSCC 2002a).

While many landslides result in sediment delivery that routes to downstream habitat, the most devastating mass wasting events are those that initiate debris flows that travel through bull trout spawning and rearing areas. North Puget Sound has a higher frequency of debris flows than South Puget Sound (J. Grizzel, Washington Department of Natural Resources, pers. comm. 2003), and debris flows are generally triggered during high precipitation storm events, including rain on snow events. The history of mass wasting and debris flow impacts demonstrate the magnitude and frequency of landslide events during the timber management period that have impacted bull trout in this core area. Most of this history reflects the legacy of past road building and timber management practices, with current rules and best management practices substantially improved. Improved road maintenance through time is essential to achieving adequate sediment reduction. Even if debris flow frequencies and magnitudes approach background levels, many of the impacts that have recently occurred will be relatively long term, and habitat recovery will continue to occur over the next several decades or longer.

Numerous spawning and rearing streams have had recent debris flows travel though their anadromous bull trout reaches. After debris flow events in 1984 and 1989 in Canyon Creek, the emergency response included the use of heavy machinery in the lower reaches after both events (Nichols, pers. comm. 2002). An extensive riprap wall was constructed after the 1989 event to protect houses and other structures built on the alluvial fan, and a new channel was also excavated in the debris flow deposition zone[†]. The Jim Creek deep-seated landslide, located just downstream of Canyon Creek falls, had a 700 percent increase in annual sediment delivery from 1983 to 1991 compared to the previous period from 1940 to 1983 (Ballerini 1993). From 1983 to 1991, total coarse and fine sediment delivery from this slide was estimated to be 774,500 cubic yards. In Boulder Creek, between 1962 and 1989, the State Route 542 bridge located at river mile 0.2 was buried by flood debris at least eleven times. A 4-kilometer (2.5-mile) long reach along Boulder Creek, which had an eighteen-fold increase in landsliding area, produced much of this debris (Gowan 1989). Debris flows also traveled through Deadhorse Creek in 1962 and 1989 (Nichols, pers. comm. 2002). Landslide related dam break flood events occurred in Glacier Creek in 1962 and 1989 which resulted in surge flow and appreciable bedload movement (Nichols, pers. comm. 2002). Heavy equipment was used to dig out the State Route 542 bridges on lower Glacier and Cornell Creeks after the event in 1989 (R. Roames, Washington Department of Natural Resources, pers. comm. 2003). In the Middle Fork, Porter and Canyon Lake Creeks had debris flows through their accessible habitat in 1989, with wood and sediment removals occurring at both Mosquito Lake Road bridges (Roames, pers. comm. 2003). Clearwater Creek has had debris flows through the accessible bull trout habitat in 1975, 1983, and 1990 (Nichols, pers. comm. 2002). A Deer Creek debris flow in 1995 was initiated below a road and traveled over three miles to the river (Crown Pacific, *in litt*. 1995). In the Howard Creek drainage an estimated 2.5 million cubic meters (3.3 million cubic yards) of sediment input occurred between 1940 and 1986 from landslides in timber harvested areas (Peak Northwest 1986). The mainstem South Fork also has numerous large landslides adjacent to the river, which are chronic sources of sediment delivery, particularly fine sediment. While this is the non-glacial fork, suspended sediment[†] levels frequently exceed those in the glacially influenced North and Middle Forks (Soicher 2000).

Forest management activities have also impacted riparian conditions in the core area. The spawning and rearing areas are primarily located in forested or forest management areas, with predominately Federal forest zoning higher in each fork. Commercial forestry and rural forestry become progressively more dominant downstream in each of the forks. The lower South Fork also has agriculture zoning (Coe 2001). Riparian conditions correlate with the zoning, and overall are in better condition (increased large wood recruitment and shading) in the upper portions of the mainstem North and South Forks, and more degraded in the lower portions (Coe 2001). The mainstem Middle Fork has relatively consistent riparian conditions, and in all three forks riparian conditions in their tributaries are usually better in those streams located higher in each fork. Overall, the riparian conditions and the habitat functions associated with them are in better condition for local populations located higher in the forks, and are more degraded for local populations located further downstream (Coe 2001).

While many spawning and rearing tributaries are temperature impaired, the mainstem of the South Fork Nooksack River has the most serious temperature problems, with water temperatures as high as 24 degrees Celsius (75 degrees Fahrenheit) reported (Maudlin *et al.* 2002). The South Fork is on the Washington Department of Ecology's 303(d) list of impaired waterbodies for insufficient instream flows, elevated fine sediment, and temperature. Recent data indicate the lower river also has low dissolved oxygen levels (Doremus *et al.* 2003). Thermal impairment begins far upstream in the timber management zone. While the absence of glacial melting and the amount of snowpack influence temperatures in the South Fork Nooksack River, forest management has also affected it through removal of river and tributary riparian vegetation, through the initiation of debris flows in tributaries, through increased sediment delivery from landsliding which resulted in river channel widening and increased unvegetated gravel bars, and possibly through hydrologic changes associated with clearcutting and forest roads. In August 2001, a longitudinal temperature profile of the South Fork was created from a forward looking infrared flight (Watershed Sciences LLC 2002). The results show a fairly rapid increase in temperature progressing downstream of Wanlick Creek (river mile 34), some cooling in the vicinity of Bear Creek outlet, additional increases in temperature to approximately the confluence with Cavenaugh Creek, and cooling from this area to downstream of Skookum Creek. Thermal heating then continues downstream, in the predominately agricultural area. The cooler areas of the river identified in this flight may be important refugia for rearing, migrating adults and foraging subadults. Temperatures in lower Bear Lake outlet, Cavenaugh, Skookum, and Hutchinson Creeks were 6.5, 4.4, 3.4, and 4.9 degrees Celsius (11.7, 7.9, 6.1, and 8.8 degrees Fahrenheit) cooler, respectively, than the river that was adjacent to them. These, other tributaries, and several cool seeps identified in this flight likely provide important temperature refugia areas for bull trout in the South Fork Nooksack River. The South Fork Nooksack River has also lost its deep salmon and trout holding pools that were created by former complex logjams (Maudlin *et al.* 2002).

Recreational off-road vehicle use is high in many forest management areas in the Nooksack core area, such as in areas around Racehorse and Bear Creek Sloughs, and Hutchinson Creek. These trails have caused erosion, riparian impacts, and direct impacts by driving through anadromous streams with known and presumed bull trout use (*e.g.*, lower Hutchinson Creek and tributaries to Bear Creek Slough).

Lower Skagit core area. Timber harvest and associated road building has had impacts to habitat in a number of watersheds in the Lower Skagit core area, including the Lower White Chuck (northside tributaries), Tenas Creek, Straight Creek, Lime Creek, Illabot Creek, Upper North Fork Sauk River, and South Fork Sauk River. Approximately 40 percent of the Sauk River drainage has been logged, with about 22 percent of the National Forest System lands consisting of forested stands established after 1920 (USFS 1996). The majority has occurred outside of the Sauk Forks watershed. Areas were initially harvested via railroad systems, followed by extensive road systems in the mid-1950's to 1960's. Road densities for the Sauk drainage as a whole are 1 kilometer per square kilometer (1.6 miles per square mile), with highest densities within the Sauk River watershed, with an open road density of over 1.2 kilometers per square kilometer (2 miles per square mile) (USFS 1996).

Tributaries to the Skagit River that have been seriously impacted by forest and County roads include Finney Creek and Grandy Creek. Both streams have high sediment loads and warm water temperatures caused by landslides triggered by roads and logging, and by warm water temperatures resulting from impacts to the riparian corridor and widening of the stream channels due to high sediment loads. Both of these streams are currently on the Washington Department of Ecology’s 303(d) list of water quality impaired streams due to excessive warming and high sediment loads. Historical accounts suggest that both streams were used by native char prior to degradation caused by road building and timber harvest (Connor, *in litt*. 2003).

Some impacts to habitat in the upper South Fork Sauk River and North Fork Sauk River have occurred from recreational activities (*e.g.*, camping, recreational mining). The Buck Creek and Downey Creek local populations have had localized impacts from the Buck Creek and Downey Creek campgrounds located near the Suiattle Road.

Upper Skagit core area. Timber harvest activities continue to be a threat to bull trout habitat in the upper Skagit River watershed within British Columbia. Timber harvest is an ongoing activity within sections of Skagit Provincial Forest, British Columbia, which is located in the northwestern portion of the Upper Skagit watershed. Bull trout are designated as a “Blue Listed” species by the Provincial government, and as such receive some habitat protections from land management activities including logging. That portion of the Upper Skagit core area within Washington State is within North Cascades National Park, Ross Lake National Recreation Area, Mount Baker-Snoqualmie National Forest, and Pasayten Wilderness and therefore has generally been free of timber harvest impacts.

Snohomish-Skykomish core area. The Snohomish-Skykomish core area has had some impacts from logging and associated road building as well as impacts from various recreational activities on forest lands (camping, inappropriate use of four-wheel drive vehicles). These impacts continue to occur in the watershed. Past timber harvest activities, including removal of riparian vegetation and the construction of haul roads, has degraded stream habitat conditions in parts of the upper watershed (Pilchuck, Snoqualmie, South Fork Skykomish, Tolt Rivers).

Stillaguamish core area. Most of the Stillaguamish basin was logged by the 1940's (WSCC 1999a). It has been reported that only about 12 percent of the basin currently contains mature stands and that there are virtually no continuous forest stands of significant size (USACE and SC 2000). The North Fork spawning tributaries of Deer Creek and Canyon Creek have experienced the effects of heavy logging (Kraemer 1994). Loss of riparian cover, slope failures, stream sedimentation, peak flows, channel incision, scour, and increased stream temperatures due to logging practices have adversely affected bull trout and all other fish species in Deer Creek (WDFW 1998; USACOE and SC 2000). Other limiting factors in the North Fork include loss of deep holding pools for adults, flood flows, and low summer flows (WDFW 1998; USACOE and SC 2000). Habitat conditions in the South Fork Stillaguamish have also been degraded by logging practices, resulting in higher stream temperatures, flooding, sedimentation, and loss of large woody debris (WDFW 1998). It has been reported that 74 percent of the inventoried landslides in the Stillaguamish watershed have resulted from logging roads (22 percent) or clearcuts (52 percent), while 98 percent of the volume of sediment is associated with these two sources (WSCC 1999a). Forty percent of the 851 landslides that delivered sediment to stream channels delivered it directly to fish-bearing waters. Years of heavy logging above and adjacent to the large slide near the Gold Basin area have contributed to the sediment delivery in the South Fork Stillaguamish, and has also contributed to the loss of large woody debris in the channel and has likely resulted in the loss of juvenile rearing and adult holding habitats (USFS 1995a).

Chester Morse Lake core area. This watershed (Cedar River Municipal Watershed) experienced extensive clearcut logging from the late 1800's, beginning in western sections at low elevation and proceeding progressively eastward to high elevation basins, until a moratorium was placed on all timber harvest on City-owned lands in 1985. During that period, 84 percent (71,588 acres) of the old-growth forest in the municipal watershed was harvested. Within the core area approximately 74 percent (36,841 acres) of the old-growth forest, mostly at mid- to relatively high elevations, was harvested (City of Seattle 2000b). After 1985, within the core area only a few units in old-growth forest were harvested by the U.S. Forest Service, mostly at higher elevations. The City also harvested approximately a dozen small units in second-growth forest outside of the core area, in the lower municipal watershed. These units were not clear-cut, but were harvested using ‘new forestry’ methods (City of Seattle 2000b).

As of 1997, the forested landscape of the total core area was approximately 26 percent old growth (190+ years old) and 74 percent second-growth, ranging in age from 0 to 189 years. Of the second-growth forest, the vast majority (95.4 percent) was between 10 and 69 years of age, distributed approximately evenly in each 10-year age class, only 2.4 percent had been recently harvested (0 to 9 years old), and 2.1 percent was 70 to 79 years old.

Harvest in the municipal watershed during the next 50 years will be guided by the habitat conservation plan under which no old-growth forest will be cut and no commercial timber harvest will be conducted. Harvest of trees will be limited to thinning selected areas of forest to meet ecological objectives, for accelerating the development of late-successional and old-growth structural characteristics in second-growth forest, and to develop habitat for selected wildlife species where and when appropriate. Ecological thinning will be conducted in second-growth forest, primarily in forest from 30 to 70 years of age and restoration thinning will be conducted in young forest, primarily less than 30 years old (City of Seattle 2000b). Current forest management within this core area is not considered a threat to bull trout. In addition, substantial habitat restoration will be implemented in both aquatic and terrestrial ecosystems, including riparian corridors throughout the core area.

Puyallup core area. Logging activities in conjunction with agriculture and development have reduced summer flows, decreased riparian canopy cover[†], increased winter peak flows and increased stream sedimentation in the Puyallup River, Carbon River, and White River systems. Present and past timber harvest has reduced the ability of riparian areas to provide wood and shade to stream channels in the upper Puyallup River and upper White River watersheds, and continue to contribute fine sediments from related road construction and landslides (WSCC 1999b). These activities have severely affected major tributaries used by steelhead, and it is likely that they have adversely affected those areas used by bull trout (WDFW 1998). Intensive logging continues on private lands in the Upper Puyallup and Mowich Rivers local population. Numerous barriers exist on tributary streams as a result of poorly constructed or designed road culverts and debris jams from past forest practices (WSCC 1999b). Road densities in the Mowich River were reported to be over 1.9 kilometers per square kilometer (3.0 miles per square mile) (USFS 1998).

As a result of the flood in 1977 and subsequent cleanup operations, the Greenwater River (White River tributary) experienced a total loss of large woody debris. Sections of the Clearwater and Greenwater Rivers are on Washington State's 303(d) list for 1998 due to temperature accedences (Appendix 1), attributed to loss of riparian cover (WSCC 1999b).

Nisqually foraging, migration, and overwintering habitat. Logging has had some negative impacts to the habitat along the mid to lower reaches of the Nisqually River. Logging near unstable slopes has created major landslides in the past which have increased sedimentation and temperature and degraded salmonid spawning and rearing habitat. These impacts can also affect bull trout foraging use of these reaches. A major landslide occurred in 1991 and temporarily blocked the river; heavy sedimentation into the river resulted (WDFW 1998). Most riparian areas in the lower and mid reaches of the Nisqually River are currently second-growth stands of hardwoods and conifers, with riparian areas impacted primarily by existing dikes and encroachments due to agriculture and various residential developments (WSCC 1999c). Although historical and current use of the Mashel River by bull trout is unknown, this is the largest accessible tributary to anadromous salmonids, and has been extensively logged over the past 50 years.

Agriculture and Livestock Grazing Practices (Factor A)

Overview. Agricultural practices have affected most of the core areas within the Puget Sound Management Unit. The most significant impacts are seen in the lower elevation areas of watersheds, the mainstem rivers and major tributaries, and the estuaries. Diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation has significantly impacted the floodplains, natural hydrologic functions, and resulted in the loss of approximately 80 percent of historical estuary and wetland habitats. Practices including stream channelization and bank armoring, diking, and the removal of instream woody debris and riparian vegetation, have degraded and simplified aquatic and riparian habitats (Spence *et al.* 1996; WSCC 1999a; WSCC 1999b; WSCC 2002a; WSCC 2002b). The Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas have been significantly altered by diking of their floodplains and estuaries. These impacts have affected bull trout foraging, migration, and overwintering habitat and blocked access to many historical wetland areas.

The Skagit River delta, the largest estuary in Puget Sound, was one of the first to be converted from tidal wetlands to agriculture. The Estuarine Research Federation estimates that 93 percent of the historical wetlands in the lower Skagit have been converted by agricultural activities over the past 150 years (Dean *et al.* 2000). In the Snohomish River estuary, approximately 74 percent of the wetlands were diked and drained for agricultural purposes (WSCC 2002b) and in the lower Stillaguamish tidal marsh and wetland habitats within the anadromous zone have been reduced by 96 percent of historical levels (WSCC 1999a). Most of the major impacts occurred in the early part of the century but construction of revetments and water control structures continued into the 1960's in some areas. The Nooksack is one of the few rivers in Puget Sound where significant estuarine habitat loss from diking has not occurred, although the river was diverted from Lummi Bay to Bellingham Bay about 100 years ago.

Agricultural practices have also contributed to the loss of side channel areas and riparian vegetation in the floodplain. The effects of livestock grazing, dairy operations, and crop production often extend many miles upriver and into areas managed primarily for timber. In the Skagit, farms and pastures extend approximately 112 kilometers (70 miles) upriver to the community of Concrete. Agriculture is most pronounced in the Nooksack River core area, where farming activities comprise almost 12 percent of the entire watershed and extend at least 69 kilometers (43 miles) up the mainstem and another 16 kilometers (10 miles) up the South Fork Nooksack River. In the Stillaguamish, the construction of dikes and revetments has resulted in a loss of over 31 percent of the historical side channel habitat and the combined impact of agriculture and residential development has reduced the riparian vegetation in these areas by nearly 90 percent. With the steady increase in urbanization and population growth in Puget Sound, agricultural lands are steadily being converted to residential and urban developments. The impacts associated with this conversion will be addressed below under the Residential Development and Urbanization section.

In Washington, the Puget Sound was selected for inclusion in the National Water Quality Assessment program. Livestock production often impacts water quality with nutrients while large quantities of pesticides are often applied to crops such as potatoes, berries, and row crops, which can leach into the water table and enter streams from surface water runoff (Rao and Hornsby 2001; Spence *et al*. 1996). A number of pesticides have been detected in small streams and sloughs within agricultural and urban sites tested within Puget Sound (Bortleson and Davis 1997). In addition, elevated nutrient concentrations from animal manures and agricultural fertilizer application can contribute to excessive growth of aquatic plants and reduced levels of dissolved oxygen in Puget Sound waterbodies, which can adversely affect fish (Embrey and Inkpen 1998). The Nooksack and Samish Rivers were reported to receive the largest nutrient inputs from animal manures and agricultural fertilizers.

Nonnative plant introductions are an emerging threat to aquatic ecosystems. These have been introduced both intentionally and unintentionally in the past through agriculture practices, development, and for ornamental purposes, and are slowly replacing less aggressive native species. *Spartina spp.* (cordgrass) has invaded nearshore habitats in north Puget Sound and threatens to exclude native fish species and reduce intertidal acreage (WSCC 1999a). These intertidal areas provide critical foraging habitats for anadromous bull trout and their prey species. In a number of core areas, invasive plant species such as Japanese knotweed (*Polygonum cuspidatum*) and reed canary grass (*Phalaris arundinacea*) are invading disturbed riparian areas and stream channels, altering and impairing these habitats and impeding the restoration and natural recovery of these areas by outcompeting native vegetation, including trees, which provide more important habitat benefits such as increased shade and large woody debris. All core areas are probably affected by one or more of these species, and while lowlands are more affected, infestations can occur quite high up in the watersheds.

Chilliwack core area. Although agriculture does not occur within that portion of the mainstem Chilliwack River system in the United States, it is extensive within the lower Chilliwack system in British Columbia. Agriculture production in the Chilliwack Valley is dominated by dairy and other livestock operations, followed by row crop and greenhouse production. Within its major tributary, the Sumas River, over 48 percent of the drainage within the United States is zoned agriculture (Blake and Peterson 2002). Within British Columbia, 59 percent of the land use in the Sumas River valley is agriculture, which in addition to urban/industrial lands contributes a variety of pollutants to the Sumas

River (Healey 1997). Between 1919 and 1923, Sumas Lake was drained for flood control and to create additional farmland. This resulted in the loss of 12,000 hectares (29,600 acres) of lake habitat for fish (Slaney *et al*. 1996).

Nooksack core area. In the Nooksack River watershed, agriculture comprises approximately 12 percent of the area (Blake and Peterson 2002). Nearly all of the lower watershed is in agricultural production. Whatcom County (primarily Nooksack core area) has the highest number of dairy operations and row crop producers in all of western Washington. Whatcom County is the 12^{th} largest dairy county in the United States. Channel straightening, diking, and loss of riparian vegetation have impacted nearly all of the agricultural waterways and essentially converted what was once a vast marshland into a gridwork of drainage ditches and water conveyance channels. For example, the South Fork Nooksack River downstream of Hutchinson Creek has been extensively altered, with 60 percent of its length being diked on one or both sides, and in combination with the loss of logjams, there has been an 86 percent loss of sloughs and side channels since 1938 (Crown Pacific, Inc. 1999).

Riparian conditions are highly degraded in agricultural zoned areas, with overall near-term large woody debris recruitment potential being low in 84.9 percent, moderate in 12.3 percent, and high in only 2.8 percent of the areas sampled (Coe 2001). Most of this land use is along the mainstem Nooksack River, lower South Fork, and along the larger tributaries (Coe 2001). Several streams in these areas are listed on the Washington Department of Ecology 303(d) list as water quality impaired for parameters including temperature, dissolved oxygen, and instream flow. In many cases hydrology has also been altered and streams, including Fishtrap Creek, Pepin Creek (Double-ditch), and many of the small tributaries flowing down from the border, include appreciable areas with straightened channels that lack habitat complexity. The freshwater forage base for migrating subadults and adults is considered substantially reduced from historical conditions.

Additionally, while settings include a variety of land uses, many streams in the Nooksack watershed are seasonally or fully closed to issuance of additional instream water rights[†] because they do not meet the legally established minimum instream flows. Included in this list are the lower North Fork Nooksack River and tributaries including Bells, Kendall, and Racehorse Creeks, the Middle Fork Nooksack River drainage, and the South Fork Nooksack River and tributaries including the Skookum and Hutchinson Creeks (Blake and Peterson 2002). Mainstem tributaries that also have partial or total closures include Anderson, Smith, Tenmile, Fishtrap, Bertrand, Silver, and Wiser Lake Creeks.

While Whatcom County's Critical Area Ordinance provides for farm plan development in place of the minimum riparian buffer requirements on fish-bearing streams, a relatively small number of non-dairy farm plans have been developed to date (G. Boggs, Whatcom County Conservation District, pers. comm. 2003).

Lower Skagit core area. Agricultural practices over the past 100 years have significantly altered the natural functions of the lower river and estuary. The lower Skagit River delta and estuary was historically a huge saltmarsh and freshwater wetland complex that extended from the community of Mount Vernon to Padilla and Skagit Bays. Tide gates, pump stations, and a network of drainage canals and levees effectively drained the wetlands and created the largest subtidal agricultural area in the State. What was once a productive salmon rearing area is now drained and virtually completely blocked off to anadromous fish. The loss of sloughs and brackish water, slow-water overwintering areas, connectivity, and rearing habitat for juvenile salmon impacts the Skagit River bull trout because the duration that these prey species spend in the nearshore environment has been shortened. In addition to the loss of estuary habitat and access, agricultural practices have had significant impacts to the hydrology and water quality. The drainage network increases peak flows and velocities, and flushes sediments that would historically have been deposited in the wetlands, out into Skagit Bay. The result is a build-up of the tidal flats beyond the levees. Because the hydrologic conveyance system has reached capacity, there is currently a proposal to construct a bypass canal that would divert Skagit River floodwaters into Padilla Bay during high flow events. This action may result in the re-designation of the floodplain and open agricultural areas to development.

Water quality impacts from V-ditching and dredging of the drainage canals contributes to elevated sediment levels in the waterways and decreases the levels of dissolved oxygen during the low flow season. Extensive use of pesticides, fertilizers, and herbicides also impacts water quality within several sloughs, including Joe Leary.

Agricultural practices upstream from the city of Mount Vernon are dominated by livestock grazing and hay production. These practices impact riparian vegetation, long-term recruitment of large woody debris, and contribute to bank erosion and water quality impacts where livestock have direct access to the streams.

Stillaguamish core area. Much of the lower watershed has been significantly altered by conversion from forest to open pastures or agricultural fields, as well as to urban and rural settlements. Riparian areas have been changed the most dramatically from pre-settlement conditions, with the majority of present day riparian areas either devoid of trees or dominated by young stands of alder or second-growth conifers. Agricultural practices (commercial and non-commercial) have also contributed to poor water quality in the system, especially in the lower watershed (WDFW 1998; USACOE and SC 2000). Agricultural practices have also resulted in the channelization and dredging of many streams for flood control, resulting in the loss of instream habitat complexity. The majority of intertidal habitat in the lower Stillaguamish River basin has been altered or destroyed by a combination of draining, diking, and filling of aquatic habitats for agricultural purposes (USACOE and SC 2000). Although agriculture practices in the Stillaguamish River system have primarily eliminated or degraded bull trout foraging, migration and overwintering habitats used by subadult and adult life stages, some juvenile rearing habitats may also have been affected.

Snohomish-Skykomish core area. As elsewhere, farming in the floodplain required drainage of wetlands and channelization of many streams in the lower watershed. Several agricultural practices have been identified as having significantly impacted the floodplain and fish habitat in the lower river, including diking of the mainstem and estuary and installation of water-control structures for drainage. Most of these structures still hinder or completely block fish passage

(Marshland and French Creek Pump Stations and tide gates on many of the sloughs). The conversion of the Marshland Marsh for agricultural uses in the 1880's was the largest single loss of off-channel habitat in the watershed. Re-construction of pump stations and tide gates to provide fish passage was identified as a priority restoration need by Federal, County, and State agencies as well as the Tulalip Tribe (Haas and Collins 2001). Livestock and dairy operations impact water quality and contribute to bank erosion and loss of riparian vegetation. Fencing and the implementation of riparian buffers under the revised (2003) Critical Areas Ordinance will help to improve conditions.

Puyallup core area. Agriculture in conjunction with extensive urban growth, a large marine port, and an extensive revetment and levee system has significantly altered the lower watershed (WSCC 1999b). Many of the historical agricultural lands have now been converted into urban and residential developments. Remaining commercial and non-commercial (hobby farms) agriculture contributes to reduced riparian areas, floodplain encroachment, and reduced water quality in some parts of the lower Carbon River and White River systems (WSCC 1999b). Agriculture practices in the Puyallup River core area have primarily degraded bull trout foraging, migration and overwintering habitats used by subadult and adult life stages.

Samish River foraging, migration, and overwintering habitat. Agriculture is the major land use within this system. Agricultural practices and residential development have impacted habitat through river diking, draining and filling of wetlands (WSCC 2003). The Samish River and Friday Creek are said to have generally poor riparian conditions as a result of land conversions to non-forest land uses. Agricultural practices likely contribute to the poor water quality within the system (WSCC 2003).

Transportation Networks (Factor A)

Overview. Dunham and Rieman (1999) found that the density of roads at the landscape level was negatively correlated with bull trout occurrence. Roads not only facilitate excessive inputs of fine sediment and possible habitat degradation in streams, they also increase human access which may induce angling mortality and introductions of nonnative fishes, often create barriers to fish migration, and increase the potential for water pollution through impervious surfaces and accidental spills (Spence *et al.* 1996; MBTSG 1998; Ruediger and Ruediger 1999; Trombulak and Frissell 2000). Roads and bridges can degrade shorelines, stream channels, floodplains, and wetlands by altering hydrodynamics and sediment deposition (Trombulak and Frissell 2000). The transportation network's stream crossings also cumulatively affect large woody debris routing and distribution, and the removal of large woody debris from culvert inlets and bridge pilings is a frequent occurrence. Road systems also change the hydrology of slopes and stream channels, and can change the routing of shallow groundwater and surface flow. The impervious surfaces related to road networks have contributed to changes in timing and routing of runoff. Extensive bank armoring has often been employed where roads parallel streams and other waterways, restricting channel migration, degrading or eliminating off-channel habitats, degrading riparian areas, and generally simplifying instream habitat. Contaminants deposited from automobiles include oil, grease, hydraulic fluids, antifreeze, and particles from tires and brakes, which can make their way to fishbearing waterbodies as a component of highway runoff (Ruediger and Ruediger 1999). A widely held principle of managing for the survival and recovery of threatened and endangered aquatic species is that remaining stronghold areas for the species and associated high quality habitats be preserved and reconnected. Wilderness, National Park land, and unroaded areas contain most of the best available remaining habitat for bull trout, steelhead, and salmon (Frissell 1993; WDFW 1998).

Extensive transportation networks have been constructed within the Puget Sound region. These include unimproved and improved roadways, railways and ferry systems. There are basically four major highway systems within the Puget Sound region, which also support a number of associated arterial networks. These include the Interstate 5 corridor running north and south along Puget Sound, which crosses all west Cascade river systems discharging into Puget Sound, the State Route 20 corridor running east and west through the Skagit River watershed, the U.S. Route 2 corridor running east and west through the Snohomish-Skykomish watershed, and the Interstate 90 corridor running east and west through portions of the Lake Washington and Snoqualmie watersheds. The most intensive development in the region has occurred along these transportation corridors. Numerous arterial networks expand along these corridors, but the most dense are associated with the urban centers along the Interstate 5 corridor.

Within the management unit, a number of railways have been constructed along the lower reaches of major watersheds, along the Puget Sound nearshore, and roughly adjacent to the Interstate 5 corridor. These railways have links to the major shipping ports in the region, Port of Tacoma and Port of Seattle, which are located in what was once extensive estuarine habitat (WSCC 1999b; KCDNR and WSCC 2000). Similar to the highway and arterial road networks in the region, these railway corridors cross numerous stream systems, or travel along, or across, nearshore habitat areas. Construction of these railways has contributed to the loss of side channel habitat, the filling of estuarine habitat, the degradation of nearshore habitat, and constrained river channel migration zones (WSCC 1999a; WSCC 1999b; KCDNR and WSCC 2000; WSCC 2002a; WSCC 2002b).

A unique transportation network in the Puget Sound Management Unit is the Washington State ferry system. Although relatively small when compared to other transportation networks, infrastructure associated with ferry terminals have contributed to loss in continuity and degradation of some nearshore habitats.

Forest road networks have had and continue to have similar and in some cases greater impacts on the landscape occupied by bull trout. Due to their inherent connection to forest management, their contribution to the reasons for decline are discussed in this document under the section on “Forest Management Practices.”

Nooksack core area. The Nooksack core area has been substantially impacted by the transportation network. Forest roads have significantly increased the rate of landsliding in the core area and in many local population areas (as discussed under “Forest Management Practices,” above). A variety of State, County and private road crossings are also partial or total migration barriers to spawning and rearing or foraging habitat, some of which are discussed under the sections on “Current Distribution and Abundance” and also “Fragmentation and Isolation.” Inadequate spacing and/or frequency of cross drain culverts on lowland roads in the basin has also resulted in the redirection and concentration of surface runoff, with resulting ditch scour and sediment and pollutant delivery to streams such as Anderson Creek (Coe and Currence 2001). Stream-adjacent roads have also impacted channel migration, especially State Route 542 along the North Fork. This road has substantially reduced the North Fork Nooksack River's channel migration. In one area, less than 30 percent of the natural channel migration zone is available to the river (GeoEngineers, 2001). The traditional response to river movements toward this road has been the placement or riprap bank armoring. This road also crosses numerous bull trout spawning and rearing streams such as lower Boulder Creek. In addition to interrupting large woody debris routing, roads and bridges in these locations constrain or prevent natural channel migration. The Washington Department of Transportation has commissioned studies to determine the best long-term course of action for State Route 542, and the recommendations include relocating significant portions of the road away from the river and to the upper end of the alluvial fans (GeoEngineers 2001; Gowan 1989). Another cumulative effect of the transportation network is the interruption of large woody debris routing by culverts and bridges intercepting wood debris moving downstream. The mainstem Nooksack River and lower South Fork presently have no areas with high large woody debris recruitment potential (Coe 2001). Large woody debris jams are critical to restoring complex channel habitat, including off-channel habitats in these areas. In the North and South Forks, recruitment potential improves progressively upstream, with the best short-term opportunity for increased wood loading for the mainstem and lower North and South Forks, being the routing of trees from upstream. In addition to interrupting wood routing, bridges frequently constrict channel areas. The Mosquito Lake Road bridge over the lower North Fork has reduced the North Fork's potential channel migration area by 96 percent (GeoEngineers 2001).

Railroad corridors have also impacted this core area and its associated nearshore marine habitat. Where the railroad corridor follows the lower South Fork Nooksack River, bank armoring and channel constriction has occurred. The crossing of Jones Creek also blocks access to foraging habitat in this tributary. The railroad corridor in Bellingham Bay and Chuckanut Bay occupies former nearshore habitat and has narrow channel openings to nearshore habitat behind it, such as at Post Point and Chuckanut Bay. The railroad corridor is frequently armored with riprap where it is located across or along the nearshore habitat in Bellingham, Chuckanut, and Samish Bays. The effects of this railroad include reduced foraging areas, reduced large wood recruitment potential to nearshore habitat, and reduced shading and interruption of sediment recruitment which are important for nourishing and preventing thermal heating of surf smelt and sand lance (bull trout prey species) spawning areas. Roads and associated armoring have caused similar impacts to nearshore habitat; one example is the Lummi Shore Road, located on the northwest side of Bellingham Bay.

Lower Skagit core area. The Upper South Fork Sauk local population has had some impacts from the road leading to the Monte Cristo townsite. The tributaries on the northside of the White Chuck River have been impacted by the White Chuck River Road. Some impacts to the Tenas Creek local population have occurred from the Suiattle Road, which parallels much of the Suiattle River. The Buck Creek, Downey Creek and Sulphur Creek local populations have also had localized impacts from the Suiattle Road. The Mountain Loop Highway, which parallels much of the mainstem Sauk River and lower South Fork Sauk River, has had some impacts to habitat occupied by the Forks of the Sauk River local population. Sections of this road fall within stream riparian areas.

Upper Skagit core area. Highway 20 parallels the entire length of the mainstem of Ruby Creek and then continues adjacent to the tributary Granite Creek, the smaller of the two major tributaries to the Ruby Creek local population. This stream has been impacted by accumulations of coarse sand and fine sediment. The stream is lower in gradient than Canyon Creek, and substrates are mainly composed of cobble and sand dominated runs, riffles, and shallow pools. Habitat conditions are considered to be relatively poor for native char in Granite Creek due to the major accumulations of granitic sand, which covers much of the streambed. The accumulations of granitic sand in Granite Creek can largely be attributed to natural geological processes. However, Highway 20 has triggered several slope failures that have resulted in localized impacts to habitat in this stream (Molesworth, pers. comm. 2003).

Stillaguamish core area. The Mountain Loop Highway impacts Palmer Creek and a number of tributaries to the South Fork Stillaguamish River as it parallels the river mainstem. A recent road failure on Forest Service Road 40, part of the Canyon Creek road system, now delivers unknown quantities of sediment into a major tributary of Canyon Creek. Construction of the railroad grade and State Route 530 along the North Fork Stillaguamish River has contributed to the loss of side channel habitat and limited natural channel migration (WSCC 1999a). Overall, side channels of the North and South Forks are reported to have been decreased by about one-third of their historical levels, due to the combined effects of bank revetment, agriculture and other land uses.

Chester Morse Lake core area. The transportation system within the City of Seattle municipal watershed is extensive, including approximately 999 kilometers (621 miles) of forest roads. As of 2000, forest road density in individual stream subbasins within the Chester Morse Lake core area averaged 2.5 kilometers per square kilometer (3.97 miles per square mile) and ranged from 0.4 to 4.1 kilometers per square kilometer (1.6 to 6.6 mile per square mile) (City of Seattle 2000b). Forest road density averaged slightly less 2.4 kilometers per square kilometer (3.88 mile per square mile) in the five major tributary basins within the Chester Morse Lake core area: Chester Morse Lake 2.5 kilometers per square kilometer (4.1 mile per square mile); Upper Cedar River 2.2 kilometers per square kilometer (3.5 mile per square mile); Rex River 2.6 kilometers per square kilometer (4.2 mile per square mile); North Fork Cedar 1.7 kilometers per square kilometer (2.8 mile per square mile); and South Fork Cedar 2.9 kilometers per square kilometer (4.8 mile per square mile) (City of Seattle 2000b).

Of the 999 kilometers (621 miles) of forest road that exist within the municipal watershed, 322 kilometers (200 miles) will be decommissioned during the next 20 years as an element of the habitat conservation plan. Roads that present chronic problems such as initiating debris flows or that repeatedly deliver sediment to critical stream reaches such as bull trout spawning reaches will be prioritized under this program. Another focus of the decommissioning program will be to evaluate, remove, and/or relocate sections of forest roads that are immediately adjacent to stream courses so that sediment delivery can be eliminated and more natural stream function can be restored. Such road-related projects will be combined with other types of aquatic and terrestrial restoration projects under the habitat conservation plan whenever possible (City of Seattle 2000b). The principal goals of the road decommissioning and road improvement/maintenance programs are to reduce sediment input to surface waters so as to improve water quality and habitat for fish, especially focusing on bull trout habitat within the core area, to improve aquatic function, and to lower long-term forest road maintenance costs (City of Seattle 2000b).

Puyallup core area. Road construction has had significant impacts in this core area. In the Upper Puyallup and Mowich Rivers local population, portions of the 24, 25, and 62 Road systems have been responsible for significant sediment inputs and past debris flows as the result of road failures facilitated by past flood events (WSCC 1999b).

State Route 167 has contributed to constriction of the White River floodplain and has contributed to significant development within the floodplain by facilitating access. There is one new highway proposed for the area, an extension of State Route 167.

Mining (Factor A)

Overview. Recreational mining and commercial mining (gravel, mineral) can significantly alter the physical structure and stability of instream habitat (Spence *et al.* 1996). In-channel gravel mining can result in both upstream and downstream downcutting which further destabilizes streambanks, leads to channel simplification, changes bedload movements, and alters groundwater hydrology which may reduce summer base flows (Spence *et al.* 1996). Although there have been recent revisions to the State rules and regulations for mineral prospecting and placer mining to be more protective of aquatic species ("Gold and Fish" pamphlet; WDFW 1999), habitat impacts (especially cumulative and frequency impacts) from ongoing recreational mining are still a concern in bull trout spawning and rearing streams. The negative effects of small-scale dredge mining may be minor and localized if the extent of the dredging is small (*in re* area or length of stream), operations are timed to avoid direct excavation of salmonid eggs and fry, operators do not disturb or destabilize streambanks, vegetation, large woody debris, or boulders, and the reconfigured streambed does not reduce the stability of interstitial spawning and rearing habitats during subsequent peak flow events (MBTSG 1998).

Nooksack core area. The most significant impact recorded in this core area is from the Excelsior Mine on the Upper North Fork Nooksack River where mining spoils were dumped directly into Wells Creek, a known bull trout spawning stream (USFS 1995b). This facility operated from 1900 to 1914. A rockfall in the mid-1970's that created a partial barrier to anadromous fish in lower Wells Creek is suspected of being caused by old mine tunneling activities (USFS 1995b).

Lower Skagit core area. Mining activity in the Monte Cristo area from 1890 to 1898 may have resulted in the elimination of all fish species in the South Fork Sauk River downstream of the mining site. The concentration of heavy metals in the South Fork Sauk River associated with ore-crushing eliminated the fish and likely most aquatic life in the early 1900's for an unknown number of years (USFS 1996). Both winter run steelhead and bull trout have subsequently recolonized the area, but it is unknown how current abundance compares to pre-mining levels. Recreational mining has occurred extensively in past in the upper South Fork Sauk River basin. However, in recent years, State permits for mining in the South Fork Sauk have been routinely denied by the Washington Department of Fish and Wildlife.

Upper Skagit core area. Historical and ongoing mining activities continue to threaten bull trout habitat in the upper Skagit River watershed. Recreational mining is still allowed in the area of the Ruby Creek local population located on National Forest Service lands (Pasayten Wilderness). Mining activities include hydraulic suction dredging at a number of mining claims that were established along Ruby and Canyon Creeks prior to the Federal Wilderness designation for this area. Under current State mining regulations, suction dredging is limited to the early summer and ends just prior to the fall bull trout spawning period. However, these mining activities can have significant impacts on the morphology of the stream channel and on the distribution of spawning-sized gravel in these streams. Bull trout spawning occurs prior to the winter high flow periods which restore the stream channel to the natural bed forms that are important for providing spawning habitat.

The Azurite Mine, a large gold and silver mine located on a tributary to Canyon Creek, is a source of heavy metal contamination that may impact the native char spawning areas located downstream in Canyon and Ruby Creeks. This mine, which was closed in the 1950's, is currently being considered for designation as an EPA Superfund remediation site by the U.S. Forest Service (Molesworth, pers. comm. 2003).

Residential Development and Urbanization (Factor A)

Significant development and urbanization has occurred within portions of most core areas. The greatest impacts have been to lower mainstem river channels, estuarine, and nearshore marine habitats, but many subbasins in the lower part of major watersheds have been altered as well. Some impacts have also occurred in spawning and rearing areas such as the lower portions of Canyon Creek, Glacier Creek, Racehorse Creek, and Hutchinson Creek in the Nooksack core area. More than 50 percent of the tidal flats and intertidal areas in major embayments of Puget Sound have been lost since 1850 (Bortleson *et al.* 1980 cited in PSWQAT 2000). Some highly urbanized areas, such as Commencement Bay, have lost more than 99 percent of historical marsh habitat and more than 89 percent of historical intertidal mudflats (USACOE *et al.* 1993). More recent reports state that over 98 percent of the historical intertidal and subtidal habitats in Commencement Bay have been lost (WSCC 1999b). Many estuarine and nearshore areas of Puget Sound have been filled or have had overwater structures installed to provide upland development sites for commercial/industrial, and to some extent residential, development. They have also been dredged extensively to maintain navigation and provide access to piers. Significant portions of nearshore and shoreline habitats have also been altered with vertical or steeply sloping bulkheads and revetments to protect various developments and structures (*e.g.*, railroads, piers) from wave-induced erosion, to stabilize banks and bluffs, to retain fill, and to create moorage for vessels (BMSL *et al.* 2001). It has been estimated that one-third of Puget Sound’s shoreline has been modified, with over half of the main basin of Puget Sound having been altered (PSWQAT 2000).

Nearly 100 percent of the Duwamish estuary and Elliott Bay shoreline has been modified by some type of armoring (BMSL *et al.* 2001). In areas where nearshore habitats currently remain intact or only partially modified, development continues to threaten these habitats (WSCC 1999a; BMSL *et al.* 2001). Functional estuarine and nearshore habitats are critical to anadromous bull trout for foraging and migration (WDFW *et al*. 1997) and to their prey species (*e.g.*, herring, surf smelt, sandlance) for spawning, rearing, and migration (WDFW 2000a; BMSL *et al.* 2001).

Other impacts to shorelines include stormwater runoff from residential development and urbanization, which continues to be a significant contributor of non-point source water pollution in core areas and foraging, migration, and overwintering habitat areas (WSCC 1999a; WSCC 1999b; KCDNR and WSCC 2000). Contaminants in this runoff may include oil, grease, and heavy metals from roadways and other paved areas, and pesticides from residential developments. Recent observations of high numbers of pre-spawn mortalities in coho salmon returning to small streams in urban and developing areas of Puget Sound have caused increasing concern over stormwater runoff (Ylitalo *et al*., *in litt*. 2003). Although the implications for bull trout are uncertain, some life stages of bull trout appear to have greater sensitivity than other salmonids to some contaminants (Guiney *et al*. 1996; Cook *et al*., *in litt*. 1999), and bull trout may be exposed numerous times to nonpoint sources due to their life history and migratory behavior. Other sources of toxic contaminants are discharges of municipal and industrial waste water, leaching contaminants from shoreline structures, and channel dredging. Even though discharges from sewage treatment plants may be treated prior to discharge into receiving waters, according to the literature the treatment likely does not adequately remove potentially harmful compounds that are considered persistent, bioaccumulative, and toxic, or those that may have endocrine disrupting properties (Bennie 1999; CSTEE 1999; Daughton and Terns 1999; Servos 1999). Estuarine and nearshore areas such as Bellingham Bay and Commencement Bay are on the State of Washington 303(d) list for a number of industrial and development related contaminants. Cherry Point within the Strait of Georgia supports the largest herring stock in Washington, and it has experienced a precipitous decline. In 1993 nearly 12,000 metric tons (13,000 short tons) of herring spawned, but by 1998 that number had dropped to just over 1,181 metric tons (1,300 short tons) (EVS Environment Consultants Inc. 1999). The stock has experienced a loss of older age classes, and the authors concluded that there is a moderate likelihood that organic contaminants are incrementally affecting this stock. The decline of this stock may be affecting the forage base for anadromous bull trout in this region of Puget Sound.

Lower river channels in many core areas have been significantly altered by dredging, channelization, and the construction of dikes and revetments for flood control and bank protection. These activities have simplified once complex stream channels, degrading and eliminating important foraging, migration, and overwintering habitat for bull trout. Many historical floodplain areas that were originally diked and drained for agricultural use have been or are now being converted to residential and industrial developments. These developments can reduce or preclude options for restoration of floodplain areas important for reestablishing off-channel habitats and maintaining groundwater recharge.

Scientific studies indicate there is a strong relationship between the amount of forest cover, levels of impervious and compacted surfaces in a basin, and the degradation of aquatic systems (Klein 1979; Booth *et al.* 2002). Impervious surface associated with residential development and urbanization creates one of the most lasting impacts to stream systems. Changes to hydrology (increased peak flows, increased flow duration, reduced base flows) as a result of loss of forest cover and increases in impervious surfaces and degradation or loss of riparian areas are typically the most common outcomes of intensive development in watersheds (May *et al.* 1997; Booth *et al.* 2002). Increased peak flows and flow duration often lead to the need to engineer channels to address flooding, erosion, and sediment transport concerns. Although recent changes have been made to most regional and local development regulations to provide protection (*i.e.*, buffer zones) for riparian areas, the integrity of these areas is frequently compromised by encroachment (May *et al.* 1997). For many small stream systems, riparian areas are highly degraded or no longer exist, and their restoration is precluded by existing development. Although functional riparian areas have the capacity to mitigate for some of the adverse impacts of development (Morley and Karr 2002), they cannot effectively address significant impacts from changes to stream hydrology resulting from significant losses of forest cover (May *et al.* 1997; Booth *et al.* 2002).

Although an "imperfect measure of human influence," basin imperviousness is commonly used as an indicator of basin degradation (Booth *et al.* 2002). Reduction in forest cover and conversion to impervious surfaces can change the hydrological regime of a basin by altering the duration and frequency of runoff, and by decreasing evapotranspiration and groundwater infiltration (May *et al.* 1998, Booth *et al.* 2001). Such changes can be detected when the total percentage of impervious surface in the watershed is as low as 5 to 10 percent (Booth *et al.* 2002). Watershed degradation, however, likely occurs with incremental increases in impervious surfaces below these levels, and is exacerbated by other factors such as reduced riparian cover and pollution (Booth 2000; Karr and Chu 2000; Booth *et al.* 2002). Booth *et al.* 2002 state, "The most commonly chosen thresholds, maximum 10 percent effective impervious area and minimum 65 percent forest cover, mark an observed transition in the downstream channels from minimally to severely degraded stream conditions." They further assert, "Development that minimizes the damage to aquatic resources cannot rely on structural best management practices because there is no evidence that they can mitigate any but the most egregious consequences of urbanization. Instead, control of watershed land-cover changes, including limits to both imperviousness and clearing, must be incorporated."

To date, residential development and urbanization are believed to have primarily affected bull trout foraging, migration, and overwintering habitats, and in some cases post-dispersal rearing habitats. Because of bull trout's proclivity for cold water, the continued loss and degradation of springfed and groundwater fed tributaries providing cool water refugia in foraging, migration, and overwintering habitats will likely constrain migratory bull trout use of these areas. Generally, most past development has occurred in the lower elevations of watersheds where bull trout spawning and early rearing are not known to occur. This may change in the future as development pressures move further up into watersheds.

Fisheries Management

Directed and Illegal Harvest (Factor B). In their 1992 Draft Bull Trout/Dolly Varden Management and Recovery Plan, the Washington Department of Wildlife identified increased fishing pressure as a major contributor to char mortality (WDW 1992) and a factor in the declines of some populations (WDFW 1998). By 1994, all but two river systems in the Puget Sound Region were closed to recreational fishing for bull trout by the Washington Department of Fish and Wildlife (WDFW 1998). This closure has also included marine waters. In addition to the recreational fisheries allowed on the Skagit and Snohomish-Skykomish river systems, the Muckleshoot Tribe has a small subsistence fishery (angling) on the White River. In the past, bull trout (typically referred to as Dolly Varden) have been viewed as an undesirable species, and were often targeted for elimination in many parts of their range, or were given very liberal to no retention limits by fisheries managers (U.S. Fish Commission 1901; Crawford 1907; Bond 1992; Brown 1994; Colpitts 1997; Stuart *et al.* 1997). In the early 1900's, bull trout were caught commercially in central and southern Puget Sound with catches quickly declining in less than 10 years, indicating bull trout were once in much greater abundance in these areas (KCDNR 2000; USACOE in prep).

Although primarily localized in impact, illegal harvest of bull trout persists in some core areas and may have significant impacts to certain local populations. Bull trout in pre-spawning aggregations or on their spawning grounds are especially vulnerable to illegal harvest (Brown 1994; McPhail and Baxter 1996). Regular enforcement of spawning areas is often difficult due to the remoteness and broad distribution of these locations. Areas currently identified with high incidences or potential for illegal bull trout harvest include Excelsior campground and the reach upstream (North Fork Nooksack River); reach downstream of Sylvester’s Falls (South Fork Nooksack River); Money Creek campground (South Fork Skykomish River); Troublesome Creek campground (North Fork Skykomish River); Bear Creek Falls (North Fork Skykomish River); Downey Creek (Suiattle River); upper South Fork Stillaguamish River; upper Bacon Creek and Illabot Creek (Skagit River); Ruby Creek (Ross Lake tributary) near the confluence of Slate and Canyon Creeks; and Silver Springs Creek

Campground on the White River (USFS 1995b; WDFW 1998; G. Lucchetti, King County Department of Natural Resources, pers. comm. 2002; Molesworth, pers. comm. 2003).

Incidental Harvest (Factor B). Recreational, commercial, and Tribal salmon and steelhead harvest and associated incidental mortality of bull trout may have significantly influenced the abundance of bull trout in Puget Sound rivers. For recreational fisheries it is likely that incidental catch of native char occurs during general “trout” and salmon fisheries, and in particular during the early portion of winter steelhead fisheries (WDW 1992). The summer “trout” fisheries in systems such as the South Fork Nooksack River should be evaluated, as foraging or migrating bull trout may already be stressed due to thermal impairment of waters, and in systems such as Ross Lake, where bull trout occupy cold water refugia at tributary outlets during summer months. Although incidental hooking of native char has been documented throughout Puget Sound rivers, Brown (1994) noted that during the mid- to late-summer period of staging, pre-spawning aggregations are especially susceptible to angling mortality. Bull trout are an aggressive apex predator, and they are highly vulnerable to incidental hooking from these and other targeted fisheries. In fact, fish biologists have found one of the most successful tools for sampling bull trout is hook-and-line fishing (Brown 1994). For example, hook-and-line sampling has been used to collect bull trout for research purposes in the Nooksack, Skagit, Snohomish-Skykomish, and Chester Morse systems as well as in marine waters.

The current level of incidental bull trout harvest in other fisheries (gill net and seine) within the Puget Sound Management Unit is not known at this time. Incidental catches of bull trout have been noted in the Puyallup and Nooksack Rivers (B. Smith, Puyallup Tribe, pers. comm. 1998; A. Kamkoff, Lummi Nation, pers. comm. 2000), and likely occur in other river fisheries. Additional or more focused effort on monitoring bull trout catches is needed to determine the level of incidental harvest in other fisheries and ultimately where and when this incidental harvest may significantly impact progress towards bull trout recovery. As additional information is gathered, it is anticipated that harvest management actions developed for other fisheries will integrate measures that minimize negative impacts to bull trout where incidental harvest significantly impedes recovery. Determining the level of incidental harvest in core populations with currently limited adult abundance, such as the Puyallup and Stillaguamish core areas, is critically important.

Habitat (Factor A). Fisheries managers have also been partially responsible for past habitat degradation. Managers from the 1950's to 1970's promoted the removal of large woody debris and log jams from streams because they were perceived to hinder fish migration (Murphy 1995). This practice eliminated or greatly reduced the habitat complexity in many streams.

Nonnative Species (Factor E). A number of nonnative species have been introduced by fisheries managers in the Puget Sound region. Nonnative fish stocking may negatively impact bull trout through competition and/or predation. Westslope cutthroat trout populations have become common in headwater streams below the alpine lakes where they were originally stocked, many overlapping with native char populations. Examples include Higgins Creek, Deer Creek, and upper South Fork Stillaguamish River in the Stillaguamish system; South Fork Sauk River, Illabot Creek, and White Chuck River in the Skagit system; and Goblin Creek in the North Fork of the Skykomish River (Downen, *in litt*. 2003). These populations of cutthroat are resident and develop piscivorous life histories in habitats where bull trout emerge from the gravel, and therefore may constitute a competitive and predatory risk to depressed populations.

Brook trout pose an additional threat to bull trout due to hybridization (Markle 1992) and competition (MBTSG 1996a). Brook trout appear to adapt better to degraded habitats than bull trout (Clancy 1993; MBTSG 1996a). Because elevated water temperatures and sediments are often indicative of degraded habitat conditions, bull trout may be subject to stresses from both interactions with brook trout and degraded habitat (MBTSG 1996a). In laboratory tests, growth rates of brook trout were significantly greater than those for bull trout at higher water temperatures when the two species were tested alone, and growth rates of brook trout were greater than those for bull trout at all water temperatures when the species were tested together (McMahon *et al.* 1998, 1999).

Brook trout have been widely introduced throughout the State of Washington and in 1992 approximately 10 percent of current range of bull trout also contained brook trout (Mongillo and Hallock 1993). Naturalized populations of brook trout within the Nooksack, Upper Skagit, and Puyallup core areas overlap with bull trout spawning and rearing habitat in parts of these watersheds. In the Nooksack core area, brook trout are well established in many areas both upstream of and overlapping with bull trout distributions. They are established upstream of Nooksack Falls, and in Wells and Glacier Creeks (USFS 1995b). Huddle (pers. comm. 2003a) has reported brook trout in numerous areas in the Nooksack system, including a small anadromous tributary adjacent to the North Fork at Excelsior Campground commonly referred to “Excelsior Terrace Tributary,” and “Bottigers Pond” which drains into Cornell Slough. Brook trout are also thought to inhabit Racehorse Creek upstream from the falls, and are known to exist in two lakes within the Kendall Creek drainage, with spawning observed at the Sumas Kendall road crossing. Huddle also notes that brook trout have been stocked in lakes in Canyon Creek upstream from the falls including in Bear Paw Lake, in a small pond in the upper Canyon Lake Creek drainage, and in Bear Lake and “Three Lakes” in the upper South Fork Nooksack River. Hybridization was detected between resident Dolly Varden and brook trout in a sample collected in Canyon Creek upstream from the falls (USFS 1995b). Through the 1970’s the Washington Department of Game released brook trout into beaver ponds in Hutchinson Creek, and brook trout were observed in an inlet channel to Musto Marsh in the 1990’s (WDNR 1998). Snorkel surveys recorded a transition from juvenile bull trout (lower) to brook trout (higher) in Hutchinson Creek downstream from Musto Marsh in 2002 (Ecotrust, *in litt*. 2002). In the Upper Skagit core area, brook trout have been detected in Hozemeen, Silver, Lightning, and Canyon Creeks. Brook trout are also present in Ross Lake (Johnston 1989) and so are presumed to have access to all adfluvial bull trout spawning and rearing tributaries within the Upper Skagit core area. In the upper Skagit River tributary, Nepopekum Creek (British Columbia), mature brook trout have been observed in the same spawning area as Dolly Varden (McPhail and Taylor 1995), which is also accessible to migratory bull trout. In the Puyallup core area, limited surveys have detected brook trout in the mainstem upper Carbon River and its tributaries (Isput, Ranger, and Chenuis Creeks), and they are believed to pose a significant threat to bull trout in this system (USFS 1998;

Samora, *in litt*. 1997; Craig, in *litt*. 2000b). Brook trout have also been detected in bull trout spawning and rearing areas of the upper White River (*e.g.*, Doe Creek and Sunrise Creek), West Fork White River (unnamed tributary, stream catalog no. 0226) and Puyallup River (Mowich River) (MRNP, *in litt*. 2001), as well as in potential spawning and rearing areas in the Greenwater River (Twentyeight Mile Creek and George Creek) of the Puyallup core area (Stagner, pers. comm. 2003). Although hybridization with brook trout has been identified as a significant threat to bull trout in other parts of its range, the full extent that brook trout introductions have impacted Puget Sound populations is currently unknown. Because the replacement of bull trout populations by brook trout has been documented in other parts of their range (MBTSG 1996a), the potential for bull trout displacement by hybridization and competition remains a significant concern in the Puget Sound Management Unit, and should be assessed more closely as soon as possible.

Hatcheries (Factor E). Bull trout have not been extensively cultured in hatcheries in any part of the species' range. The absence of bull trout hatcheries within Washington State has limited the potential biological risks associated with hatcheries (*e.g.*, loss of genetic diversity within and among stocks, interbreeding between hatchery and wild fish, competition with or predation by hatchery fish, disruptive behavior, effects on non-target species, disease, depletion of wild stocks for broodstock, and escapement). For the Puget Sound Management Unit, the use of hatcheries or supplementation in bull trout recovery is believed to be unneeded and is currently not being considered in planning (McPhail and Baxter 1996; MBTSG 1996b). The potential use of hatcheries in bull trout recovery across their range has generally been limited to genetic reserves and restoration stocking in watersheds where a population has been extirpated.

How salmon hatchery operations and the interactions between hatchery-origin salmon have and may continue to affect bull trout have not been closely examined in the management unit, however, the risks to bull trout are likely limited given their life history. Hatchery activities such as weir operations and broodstock collections,may have some impacts to bull trout. It is anticipated that potential risks to bull trout will be assessed and addressed during the ongoing process of reviewing hatchery practices and integrating hatcheries in salmon recovery (*e.g.*, review of Hatchery and Genetic Management Plans (HGMP) developed for take[†] exemptions under the 4(d) rule for Puget Sound Chinook and Hood Canal summer-run chum salmon).

Forage (Prey) Base (Factor E). A number of salmon stocks have declined in abundance in the Puget Sound region. On March 24, 1999, the National Marine Fisheries Service listed the Puget Sound Chinook salmon Evolutionarily Significant Unit as threatened (64 FR 14308), while the Puget Sound-Strait of Georgia coho salmon Evolutionarily Significant Unit remains a species of concern. Declines in these and other salmon stocks threaten bull trout, since juvenile salmonids are a primary food source (Kraemer 1994). These declines are the result of a number of factors which include habitat loss and degradation as well as past fisheries management.

<u>Habitat Fragmentation and Isolation (Factor E)</u>

Improperly installed, sized, or failed culverts have been identified as barriers for fish movement and migration throughout Puget Sound Watersheds (see Forest Management and Transportation Networks sections). The Salmon and Steelhead Habitat Limiting Factors reports for Water Resource Inventory Areas (WSCC 1999a; WSCC 1999b; WSCC 1999c; WSCC 2002a; WSCC 2002b) identify numerous impassible barriers to both resident and migratory fish in the area of the Puget Sound Management Unit. For example, in the Nooksack core area road blockages affect spawning and rearing areas in Hedrick Creek, “Chainup Creek,” “Lookout Creek,” Boyd Creek, a tributary located just downstream of Boulder Creek, Johnson Creek in the Hutchinson Creek drainage, Loomis Creek, and on a tributary to the South Fork which enters near river mile 29.8. There are also a few blocking culverts in the Middle Fork upstream of the diversion dam under the U.S. Forest Service 38 road. There are numerous blockages to foraging habitat in drainages including Anderson Creek (mainstem tributary), Landingstrip Creek, Jones Creek, Kenny Creek, and in tributaries to the Bear Creek Slough complex. The construction of flood control structures, tide gates, and water diversion structures have also contributed to the degradation and fragmentation of migratory corridors, and elimination of historical foraging, migration, and overwintering habitats within the Management Unit.

The construction and operation of dams has also contributed to habitat fragmentation and isolation of bull trout in the Nooksack, Upper Skagit, Lower Skagit, and Puyallup core areas. Facilities in the Puyallup core area have only recently implemented modifications to improve fish passage. Bellingham Diversion on the Middle Fork Nooksack River continues to be a barrier to fish passage. It should be noted that volitional fish passage is currently not feasible for many facilities. Given bull trout's complex migratory behavior at various life stages, assisted passage may limit full expression of this behavior. The significance of this limitation to populations is currently unknown, but likely affects primarily the movements of the subadult life stage.

Reasons for Decline Summary

Chilliwack core area. Habitat within the United States portion of the population is virtually in excellent to pristine condition, with the exception of the agriculturally dominated Sumas River. However, the vast majority of the Chilliwack River system lies within British Columbia, Canada. Most impacts to this core area occur within British Columbia where a number of land management activities have and continue to impact the Chilliwack River basin. Forest practices and agriculture practices have likely had the most widespread and lasting impacts to bull trout habitats within the system. Residential development and urbanization have primarily impacted foraging, migration, and overwintering habitats for bull trout. These factors primarily affect those life history forms that migrate through mainstem river areas, to the Fraser River, and/or to nearshore waters in the Strait of Georgia. Current fisheries management in British Columbia allowing the retention of bull trout does reduce the number of spawners returning to spawning areas in the United States, however the overall impact to the sustainability of the Chilliwack core area is currently unknown.

Nooksack core area. Past forest practices and related road networks and mass wasting have had some of the most significant impacts to bull trout habitat within this core area. These have resulted in the loss or degradation of a number of spawning and rearing areas within local populations, as well as foraging, migration, and overwintering habitats. Bellingham Diversion has significantly reduced if not precluded connectivity of the Upper Middle Fork Nooksack River local population with the rest of the core area. Bellingham Diversion currently prevents most anadromous and fluvial bull trout returning to the Middle Fork Nooksack River from reaching spawning and rearing habitats in the upper watershed. Agriculture practices, residential development, the transportation network and related stream channel and bank modifications have resulted in the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks, as well as in a number of tributaries. Marine foraging habitats for this core area have and continue to be greatly impacted by urbanization along nearshore habitats in Bellingham Bay and Strait of Georgia. The presence of brook trout in many parts of the Nooksack core area and their potential to further increase in distribution is of significant concern given the level of habitat degradation that has occurred within the core area. The detection of brook trout/Dolly Varden hybrids further emphasizes this threat to bull trout. The absence of established spawner index areas or other repeatable means of monitoring bull trout population abundance and distribution within the core area, continues to hinder the identification, conservation, and restoration of remaining spawning and rearing reaches within the core area.

Lower Skagit core area. Large portions of this core area fall within areas under National Park and Wilderness designation, so these areas have generally avoided many of the impacts from more intensive land management. Gorge Dam currently restricts connectivity between the Stetattle Creek local population and the majority of the core area. This has put the Stetattle Creek local population at increased risk, however this break in connectivity may be less significant to the core area as a whole due to the large number of connected local populations that exist below this barrier. The Baker Dams also restrict connectivity between the Baker Lake local population and Sulphur Creek potential local population and the rest of the core area. Operations of the Lower Baker Dam have at times significantly impacted water quantity in the lower Baker and Skagit Rivers. Agriculture practices, residential development, the transportation network and related stream channel and bank modifications have resulted in the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks, as well as in a number of tributaries. Nearshore foraging habitats have and continue to be impacted by agricultural practices and development activities. Bull trout within this system were overharvested in the past, but the implementation of more restrictive regulations in the early 1990's have helped allow the population to increase in abundance from the low levels of the late 1980's. Recent spawning index area counts strongly indicate that this population is rebounding near or to recovered levels.

Upper Skagit core area. Much of the habitat within the United States portion of the population is virtually in excellent to pristine condition. The most significant habitat change resulted from of the formation of Ross Lake, which eliminated the mainstem habitat of the Skagit River. The formation of the lake created access to a number of steep tributaries now used for spawning and rearing, and although uncertain, may have completely compensated for this mainstem habitat loss. In the United States, the majority of the core area falls within National Park, Wilderness designation, and Recreational Area designation, so it has generally avoided impacts from more intensive land management. There are some tributaries (e.g., Hozemeen Creek) which have not yet recovered from past timber harvest activities. Ross Dam currently restricts connectivity between the Thunder Creek local population and the majority of the core area. This has put the Thunder Creek local population at increased risk. However, this break in connectivity may be less significant to the core area as a whole due to the number of local populations that exist above this barrier both in the United States and in Canada. Past and ongoing forest practices have impacted bull trout habitats that lie within British Columbia. Recreational mining activities continue to impact some key local populations. Brook trout are established in a number of tributaries to Ross Lake, which are also used by bull trout for spawning and rearing. In some tributaries (*e.g.*, Hozemeen Creek), brook trout appear to have replaced or displaced bull trout that were likely once dominant in the system.

Stillaguamish core area. Past forest practices and related road networks and mass wasting have had some of the most significant impacts to bull trout habitat within this core area. These have resulted in the degradation of a number of spawning and rearing areas within local populations, as well as foraging, migration, and overwintering habitats. Ongoing mass wasting delivers significant amounts of sediment to this system, resulting in the loss of deep pools and elevated water temperatures. Like most major river systems within the Puget Sound Management Unit, habitat complexity has been significantly reduced in the mainstems and intertidal habitats have been largely eliminated as a result of various land management and development activities. This has resulted in the degradation of foraging, migration, and overwintering habitat and potentially rearing habitat for the anadromous life history form. Past fisheries on bull trout, up until the early 1990s, likely resulted in a significant reduction of the overall core population. Given the low abundance of migratory adults, current legal and illegal fisheries within the Stillaguamish core area may significantly limit the ability of the population to recover. The absence of established spawner index areas or other repeatable means of monitoring bull trout population abundance and distribution within the core area continues to hinder the identification, conservation, and restoration of remaining spawning and rearing reaches within the core area.

Snohomish-Skykomish core area. Many of the key spawning and rearing habitats of local populations within the North Fork of the Skykomish River remain in good to excellent condition. Past and recent timber harvest and associated road building has impacted habitats primarily within the South Fork Skykomish River local population. Like most major river systems within the Puget Sound Management Unit, habitat complexity has been significantly reduced in the mainstems as a result of various land management and development activities. This has resulted in the degradation of foraging, migration, and overwintering habitat and potentially rearing habitat for the anadromous life history form. Nearshore foraging habitats have and continue to be impacted by development activities. Bull trout within this system were overharvested in the past, but the implementation of more restrictive regulations in the early 1990's have helped allow the population to increase in abundance from the low levels of the late 1980's. Recent returns strongly indicate that this population has likely rebounded near or to recovered levels of abundance.

Chester Morse Lake core area. Past forest practices and reservoir management have likely had the most significant impacts to bull trout habitat within the core area. Although the adult spawner abundance appeared to be at extremely low levels in the 1990's, recent returns strongly indicate that this population has likely rebounded near or to recovered levels. Past and current flood events have likely been exacerbated by the existing forest conditions, but are expected to improve over time given current forest management under the City of Seattle’s Cedar River Habitat Conservation Plan. A number of actions being conducted under the habitat conservation plan are directed at restoring and protecting bull trout habitats within the core area, managing the reservoir to minimize negative impacts to bull trout, and monitoring the distribution and abundance of the bull trout population.

Puyallup core area. Although significant portions of the known spawning and rearing areas for bull trout remain protected within Mount Rainier National Park lands, past and present timber harvest and related road building continue to impact spawning and rearing areas in the upper Puyallup River system, while agriculture practices continue to impact foraging, migration, and overwintering habitats for bull trout in the lower watershed. Dams and diversions have had some of the most significant impacts to migratory bull trout in the core area. The Electron Diversion Dam had isolated bull trout in the upper Puyallup and Mowich Rivers from the rest of the Puyallup core area for nearly 100 years until passage was recently restored. The facility has drastically reduced the abundance of migratory life history forms in the Puyallup River. Buckley Diversion and Mud Mountain Dam have had some of the most significant impacts to the White River system. In the past, these facilities impeded or precluded adult and juvenile migration, and degraded mainstem foraging, migration, and overwintering habitats. Although improvements have been made, some of these impacts continue today, but to a lesser degree. Urbanization and residential development and the marine port have significantly reduced habitat complexity and quality in the lower mainstem rivers and associated tributaries, and have largely eliminated intact nearshore foraging habitats for anadromous bull trout within Commencement Bay. The presence of brook trout in many parts of the Puyallup core area including National Park waters and their potential to further increase in distribution is considered a significant threat to bull trout. Brook trout in the Upper Puyallup and Mowich Rivers local population is of highest concern given the past isolation and the level of habitat degradation that has occurred within parts of the local population. Past fisheries on bull trout, up until the early 1990's, likely resulted in a significant reduction of the overall core population. Given the low abundance of migratory adults, current legal and illegal fisheries within the Puyallup core area may significantly limit the ability of the population to recover. The absence of established spawner index areas or other repeatable means of monitoring bull trout population abundance and distribution within the core area, continues to hinder the identification, conservation, and restoration of remaining spawning and rearing reaches within the core area.

ONGOING CONSERVATION MEASURES

The overall recovery implementation strategy for the Coastal-Puget Sound Distinct Population Segment is to integrate with ongoing Tribal, State, local, and Federal management and partnership efforts at the watershed or regional scales. This coordination will maximize the opportunity for complementary actions, eliminate redundancy, and make the best use of available resources for bull trout and salmon recovery.

State of Washington

Salmon Recovery Act. The Governor's office in Washington State has developed a statewide strategy that describes how State agencies and local governments will work together to address habitat, harvest, hatcheries, and hydropower as they relate to recovery of listed species of salmonids (WGSRO 1999). The Salmon Recovery Act, passed in 1998 (Engrossed Substitute House Bill 2496), provides the structure for salmonid protection and recovery at the local level (counties, cities, and watershed groups).

The Salmon Recovery Act directs the Washington State Conservation Commission, in consultation with local governments and treaty Tribes, to invite private, Federal, State, Tribal, and local government personnel with appropriate expertise to convene as a technical advisory group for each Water Resource Inventory Area (WRIA) of Washington State. Water Resource Inventory Areas are generally equivalent to the State's major watershed basins. The purpose of the technical advisory group is to develop a report identifying habitat limiting factors for salmonids. This report is based on a combination of existing watershed studies and knowledge of the technical advisory group participants. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae."

The bill further clarifies the definition by stating, "These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands." It is important to note that the responsibilities given to the Conservation Commission do not constitute a full limiting factors analysis.

Salmon Recovery Funding Board. In 1999, the Washington State Legislature created and authorized the Salmon Recovery Funding Board to guide spending of funds targeted for salmon (the term was used broadly to include all species of salmon, trout, char, whitefish, and grayling) recovery activities and projects. The Salmon Recovery Funding Board's mission is "to support salmon recovery by funding habitat protection and restoration projects, and related programs and activities that produce sustainable and measurable benefit for the fish and their habitat." The primary role of the Board is to fund the best salmonid habitat projects and activities reflecting local priorities and using the best available science, to protect, preserve, restore and enhance salmonid habitat and watershed functions. Under current funding policies, the Salmon Recovery Funding Board will give the greatest preference to strategies and project lists that benefit salmonid populations that are listed under the Endangered Species Act.

Washington Department of Fish and Wildlife. The Washington Department of Fish and Wildlife has developed a native char management plan that addresses both bull trout and Dolly Varden (WDFW 2000b). The Washington Department of Fish and Wildlife no longer stocks brook trout in streams or lakes connected to bull trout waters. Fishing regulations prohibit harvest of bull trout, except for a few areas where stocks are considered "healthy" by the State of Washington. The Washington Department of Fish and Wildlife is also currently involved in a mapping effort to update bull trout distribution data within the State of Washington, including all known occurrences, spawning and rearing areas, and potential habitats. The salmon and steelhead inventory and assessment program is currently updating their database to include the entire State, which consists of an inventory of stream reaches and associated habitat parameters important for the recovery of salmonid species including bull trout. This database will provide critical baseline habitat and fish distribution information that can be used in a number of conservation efforts.

Harvest for bull trout has been significantly reduced across the species' range. Most recreational fisheries for bull trout in fresh and marine waters in the Coastal-Puget Sound Distinct Population Segment have been closed since 1994. There are only two river systems in western Washington where directed recreational harvest of bull trout is currently allowed by the Washington Department of Fish and Wildlife, the Skagit and Skykomish Rivers. In these two systems, a two fish retention limit with a minimum harvest size of 508 millimeters (20 inches) was established in 1990 to allow all migratory individuals the opportunity to spawn at least once to increase spawner abundance levels. To date, this management action has succeeded in increasing spawner abundance levels in these two systems. As the Coastal-Puget Sound Distinct Population Segment begins to achieve its recovery goal, the Washington Department of Fish and Wildlife and Tribes in coordination with the U.S. Fish and Wildlife Service will determine the location and level of bull trout harvest that continues to support the population characteristics consistent with bull trout recovery.

The Washington Department of Fish and Wildlife's Hydraulic Project Approvals program reviews and permits or denies projects that propose to use, obstruct, divert or change streambeds or flows, or impact nearshore marine waters in the State of Washington. Updates that have been made within the program to help conserve bull trout and their habitat include: revised rules and regulations for mineral prospecting and placer mining to reduce impacts to bull trout and bull trout habitat; revised approved work windows (periods of time for inwater work) that provide greater protection for bull trout life stages during spawning and incubation; and development of marine work windows that help protect important marine forage (prey) fish species for bull trout.

The Washington Department of Fish and Wildlife in conjunction with the Northwest Indian Fisheries Commission have been using Ecosystem Diagnosis and Treatment (EDT) modeling for deriving recovery goals for Puget Sound Chinook salmon in terms of productivity, capacity, and diversity based on properly functioning conditions for habitat. The model is used to analyze environmental information and draw conclusions about the ecosystem as it relates to the life history of Chinook salmon in this case. This approach compares existing conditions with a future condition where conditions are as good as they theoretically can be within the watershed. From this comparison, a "diagnosis" of factors that are preventing achievement of this future condition can be made, and potential actions to achieve goals can be identified. It is anticipated that many of the limiting habitat factors for Chinook salmon identified through this model will be equally or partially applicable to bull trout.

Washington Department of Ecology. The Washington Department of Ecology is involved in a number of programs and actions intended to help provide greater conservation for bull trout and other salmonids by reducing habitat impacts. These include updating the State's Stormwater Management Manual for construction and development, updating State Shoreline Management regulations, updating the State's Water Quality Standards, and developing and implementing water cleanup plans, or TMDLs (total maximum daily loads) for impaired waterbodies.

Shoreline Management Act. The goal of the Shoreline Management Act (Revised Code of Washington [RCW] 90.58) is "to prevent the inherent harm in an uncoordinated and piecemeal development of the State's shorelines." This act establishes a balance of authority between local and State government. Cities and counties are the primary regulators but the State has authority to review local programs and permit decisions. The Shoreline Management Act gives preference to uses that:

- Protect the quality of water and the natural environment.
- Depend on proximity to the shoreline.
- Preserve and enhance public access or increase recreational opportunities for the public along shorelines.

The Shoreline Management Act also requires extra protection for management of "shorelines of statewide significance." These shorelines include Pacific Coast, Hood Canal, the Strait of Juan de Fuca, and large rivers (1,000 cubic feet per second or greater for rivers in western Washington) (WDOE 1999).

The National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management funds the Shoreline Management Act and is responsible for approving the guidelines and incorporating them into the federally approved Washington Coastal Zone Management Program. As part of the approval process, the Office of Ocean and Coastal Resource Management must comply with the Endangered Species Act, which requires consultation with us and the National Oceanic and Atmospheric Administration (NOAA) Fisheries.

Growth Management Act. The goal of the Growth Management Act is to prevent uncoordinated and unplanned growth that poses a "threat to the environment, sustainable economic development, and the health, safety, and high quality of life enjoyed by residents of this State" (RCW 36.70A.010). Under the Growth Management Act, the State provides broad public access to data and maps describing development opportunities and constraints. The Growth Management Act is widely used as a framework for other State statutes and policies related to land-use practices, environmental protection, and sustainable development (Washington State Department of Community, Trade, and Economic Development, no date). The Growth Management Act requires all cities and counties in the State to:

- Designate and protect wetlands, frequently flooded areas, and other critical areas;
- Designate farm lands, forest lands and other natural resource areas;
- Determine that new residential subdivisions have appropriate provisions for public services and facilities.

Washington Department of Natural Resources. The Washington Department of Natural Resources manages State trust lands for terrestrial, riparian, aquatic, and special habitats under their habitat conservation plan, approved by us in 1997. The Washington Department of Natural Resources manages State trust lands similarly throughout the western Cascade Mountains and southwest Washington. Approximately 540,000 acres within the Puget Sound Management Unit are covered by this habitat conservation plan. The riparian conservation strategy for these lands has two conservation objectives: 1) maintain or restore salmonid freshwater habitat on Washington Department of Natural Resources managed lands, and 2) contribute to the conservation of other aquatic and riparian obligate species.

These two objectives will be achieved by the following activities along Type 1, 2, and 3 Waters (fish bearing waters described in the Washington Administrative Code 222-16-031): 1) the width of the riparian buffer shall be approximately equal to a site potential tree height; 2) no timber harvest shall occur within the first 7.6 meters (25 feet) from the outer margin of the 100 year floodplain primarily to maintain stream bank integrity; 3) the next 22.8 meters (75 feet) of the buffer shall be a minimum harvest area, that may include ecosystem restoration and the selective removal of single trees, to maintain natural levels of stream temperature, sediment load, detrital nutrient load, and instream large woody debris; and 4) the area beyond 30 meters (100 feet) to approximately a site potential tree height from the active channel margin shall be a low harvest area.

The riparian buffer on Type 4 streams will be 30 meters (100 feet) wide measured horizontally from the outer margin of the 100-year floodplain. The zone will be managed similar to the two inner zones described above for Type 1, 2 and 3 streams. Type 5 streams flowing through high risk mass wasting areas will be protected when necessary for water quality, fisheries habitat, stream banks, wildlife, and other important elements of the aquatic system for the first 10 years of the plan, then protected according to a long-term plan incorporating an adaptive management strategy.

In addition to providing riparian buffers to fish bearing and non-fish bearing streams, this habitat conservation plan provides for wind buffers on Types 1, 2, and 3 streams in areas that are prone to windthrow. Wind buffers will be 15 to 30 meters (50 to 100 feet) along the windward side or possibly both sides depending on the intensity and direction of potential windthrow, and the stream size.

The habitat conservation plan strives to minimize adverse impacts to salmonid habitat caused by the road network by developing a comprehensive landscape-based road network management process that will include such elements as: 1) minimization of active road density; 2) a base-line inventory of all roads and stream crossings; 3) prioritization of roads for decommissioning, upgrading, and maintenance; and 4) identification of fish blockages caused by stream crossings and a prioritization of their retrofitting or removal.

The forest management described in the riparian conservation strategy for the Washington Department of Natural Resources Habitat Conservation Plan is expected to result in improved salmonid habitat by developing older conifer forest in the riparian zone, developing greater root strength and hydrologic maturity of young forests on unstable slopes, and ameliorating the adverse impacts of roads through the comprehensive road management plan.

Washington State Forest Practices Rules. In July 2001, the Washington Forest Practices Board adopted new permanent forest practice rules implementing the Forest and Fish Report (FFR 1999; WFPB 2001). The Forest and Fish Report was the result of a document development process that relied on broad stakeholder involvement, including the U.S. Fish and Wildlife Service, the National Marine Fisheries Service (now NOAA Fisheries), and the U.S. Environmental Protection Agency, as well as State agencies, Counties, Tribes, forest industry and environmental groups. Prior to completion of the Forest and Fish Report, the environmental groups withdrew their support and participation in the process. The forest practices rules established new prescriptions to better conserve aquatic and riparian habitat for bull trout and other salmonids, and many provisions of the rules represent improvements over previous regulations. Because there is biological uncertainty associated with some of the prescriptions, the Forest and Fish Report relies on an adaptive management program for assurance that the new rules will meet the conservation needs of bull trout. Research and monitoring being conducted to address areas of uncertainty for bull trout include protocols for detection of bull trout, habitat suitability, forest management effects on groundwater, field methods or models to identify areas influenced by groundwater, and forest practices influencing cold-water temperatures.

Dairy Nutrient Management Act. The Dairy Nutrient Management Act (RCW 90.64), overseen by the Washington Department of Agriculture, and local Manure Management Ordinance require farm plans for dairies but not for other livestock operations. Virtually every dairy farm in Whatcom County is operating under an approved farm plan. These plans are designed to protect ground and surface water quality and include, at a minimum, a grass filter strip on all water courses (G. Boggs, Whatcom County Conservation District, pers. comm. 2003).

Washington State Conservation Reserve Enhancement Program. The national Conservation Reserve Enhancement Program, implemented by the Natural Resources Conservation Service, dedicates $250 million annually for restoration activities on agricultural lands in Washington State. Farmers and landowners receive reimbursements in the form of soil rental rates for taking land out of production to plant riparian buffers, fence livestock out of streams, and restore stream habitat. Whatcom County has the greatest number of sign-ups with 85 contracts (over 405 hectares; 1,000 acres) since the program began in 1998. Whatcom is followed by Skagit County with 60 contracts (nearly 125 hectares; 390 acres), Lewis County with 13 contracts (162 hectares; 400 acres) and Snohomish County with 7 contracts (33 hectares; 83 acres). Approximately 12 to 16 hectares (30 to 40 acres) total are under contract in King, Pierce, and Thurston Counties where agricultural lands are limited. The Conservation Reserve Enhancement Program contracts are 10 to 15-year terms and restored riparian areas are often incorporated into conservation easements to provide permanent protection.

<u>Federal Agencies</u>

U.S. Fish and Wildlife Service. Aside from the Endangered Species Act regulations and guidelines that apply to Federal actions (see Appendix 4), there have been several significant Federal efforts with specific implications for bull trout in the Puget Sound Management Unit. We also have a number of national programs (*e.g.*, Private Stewardship Program, Cooperative Endangered Species Conservation Fund) that can and have provided funds to projects restoring and conserving bull trout habitats in Puget Sound.

We have negotiated several habitat conservation plans within the area of the Puget Sound Management Unit. The Washington Department of Natural Resources Habitat Conservation Plan is discussed above; the other plans are discussed below.

The City of Seattle’s Cedar River Watershed Habitat Conservation Plan was implemented in April 2002. This habitat conservation plan addresses Chester Morse reservoir operations and activities associated with restoration planting of about 567 hectares (1,400 acres); restoration thinning of about 4,451 hectares (11,000 acres); ecological thinning of about 809 hectares (2,000 acres); instream habitat restoration projects; removal of approximately 386 kilometers (240 miles) of road over the first 20 years; maintenance of about 836 kilometers (520 miles) of road per year at the start of the habitat conservation plan, diminishing as roads are removed over time to about 611 kilometers (380 miles) per year at year 20; and improvement of about 6.4 to 16.1 kilometers (4 to 10 miles) of road per year. In addition, the habitat conservation plan outlines a number of bull trout research projects in Chester Morse Lake and upper Cedar River system. The results of these projects will help inform and guide future management. The term of the City of Seattle Habitat Conservation Plan and incidental take permit is 50 years.

The Tacoma Water Habitat Conservation Plan was implemented in July 2001. This habitat conservation plan addresses effects to listed species from Tacoma Public Utilities management of 6,070 hectares (15,000 acres) of forest in the upper Green River Watershed, including approximately 177 stream kilometers (110 stream miles), and Tacoma's municipal water withdrawal from Green River at river mile 61.0. Distribution of bull trout in the upper watershed has not been documented and only a few individuals have recently been found in the lower Green River and the Duwamish Waterway (USFWS 2001). The U.S. Fish and Wildlife Service permitted the incidental take of bull trout resulting from water withdrawal activities affecting the middle and lower Green River, even-aged harvest of 1,329 hectares (3,285 acres), uneven-aged harvest of 809 hectares (2,000 acres), and the construction, maintenance, and decommissioning of 181 kilometers (113 miles) of road. This plan also includes the construction of an adult trap and haul facility and juvenile passage facility for anadromous salmonids at the Tacoma Headworks diversion dam. The term of the Tacoma Water Habitat Conservation Plan and permit is 50 years.

The Plum Creek Habitat Conservation Plan was implemented in June 1996. The U.S. Fish and Wildlife Service permitted the incidental take of the spotted owl, marbled murrelet, grizzly bear, and gray wolf, in the course of the otherwise legal forest-management and related land-use activities carried out under the plan in portions of King and Kittitas Counties, Washington. The permit was amended to include the Columbia River population segment of bull trout in

1998, and the Coastal-Puget Sound population segment of bull trout in 2002. The term of the plan and incidental take permit is 50 to 100 years, as some aspects of the plan and permit may terminate at year 50 while others may continue for an additional 50 years. Plum Creek's ownership within the covered area is located both east and west of the Cascade Mountains crest along the Interstate-90 corridor in central Washington. Plum Creek's ownership covered by the plan on the west side of the Cascade crest is approximately 21,450 hectares (53,000 acres), primarily composed of the upper Green River watershed. Recent surveys of the habitat conservation plan lands west of the Cascade crest have not detected bull trout, but surveys are not comprehensive. The Riparian Management Strategy in the habitat conservation plan includes the maintenance and protection of riparian habitat areas. These riparian habitat areas and wetlands total about 1,255 hectares (3,100 acres) in Plum Creek's lands west of the Cascade Crest. Minimum guidelines in these areas include establishing 60-meter (200-foot) buffers (measured as horizontal distance from the edge of the stream) on each side of all fish-bearing streams. Other measures include some protections for riparian wetlands, west-side (of the Cascade Mountains) nonfish-bearing perennial streams, and seasonal fish-bearing streams.

The West Fork Timber (formerly Murray Pacific) Habitat Conservation Plan was issued in September 1993, and recently amended (June 2002) to include the Coastal-Puget Sound Distinct Population Segment of bull trout. The habitat conservation plan area consists of 21,662 hectares (53,527 acres) of forest land in two contiguous blocks north and northeast of the town of Morton in eastern Lewis County, Washington. The majority of the habitat conservation plan area is managed for timber production, and is currently a mosaic of coniferous forest stands of varying ages. Although approximately 100 kilometers (62 miles) of fish-bearing waters have been identified in the area, historically bull trout presence has never been detected. Similarly, bull trout have not been identified through recent surveys conducted as part of the fish monitoring program under this habitat conservation plan. In order for bull trout to migrate to the area, they would travel along the Cowlitz and Nisqually River systems. Dams on the Cowlitz and Nisqually Rivers effectively prevent the upstream migration of salmonid species. Therefore, the potential for individuals from the lower Nisqually River or other areas of Puget Sound to migrate to the area is low. The most significant measure associated with the habitat conservation plan is the conservation of at least 18 to 20 percent (4,050 hectares; 10,000 acres) of the area as a source of late-successional forest habitat. Most of these reserve areas are located in riparian zones along streams and wetlands which would benefit bull trout should they be detected in this area in the future.

Our Western Washington Fish and Wildlife Office also has a number of restoration programs (*e.g.*, Jobs in the Woods, Partners for Fish and Wildlife, Puget Sound Coastal Program) that provide funding and technical assistance for habitat restoration work in the Puget Sound region. Many of the projects funded through these programs contribute to the recovery of bull trout through habitat enhancements or through the restoration of watershed processes and functions that have been eliminated or impaired by land management activities. These programs also contribute to the restoration of estuarine and nearshore habitats important to the recovery of bull trout and salmon.

The Fisheries Restoration and Irrigation Mitigation Program provides funds for fish screening and for providing fish passage at water diversions. Industrial, municipal, and agricultural diversions are eligible for restoration and mitigation funding.

Our Western Washington Fish and Wildlife Office participates in the Federal Energy Regulatory Commission's hydroelectric project proceedings for both new projects and projects requiring a new operating license. During the license proceeding, we provide the Federal Energy Regulatory Commission with recommended measures to protect and enhance fish and wildlife, including their habitat, and may include mandatory fish passage prescriptions. The recommended measures are transmitted through the Department of the Interior's response on the license application. During project relicensing, we have an opportunity to improve habitat that has been degraded by project operation by persuading the Federal Energy Regulatory Commission to include mitigative measures (*e.g.*, improved flows, sediment and large woody debris transport, etc.) as license conditions. A hydroelectric project operating license typically covers a period of between 25 and 40 years.

U.S. Forest Service. Currently, timber management in the National Forest System within the Puget Sound Management Unit is guided by individual Forest Plans as amended by the Northwest Forest Plan (see Appendix 4). Benefits to aquatic and riparian habitat to date from the Northwest Forest Plan are evident throughout the North Cascades.

The U.S. Forest Service also conducts ongoing aquatic habitat monitoring and fish survey efforts, and continues to be involved in restoration efforts of upland and aquatic habitats on National Forest lands to benefit salmonids and other aquatic species.

North Cascades and Mount Rainier National Parks. Portions of the Lower and Upper Skagit core areas are located within the boundaries of North Cascades National Park, and portions of the Puyallup core area are located within the boundaries of Mount Rainier National Park. This largely undisturbed habitat provides important high quality spawning and rearing habitat for bull trout and other salmonids and protects some of the last undisturbed bull trout habitat in Washington. The two parks are undertaking aquatic habitat monitoring, inventories of fish populations throughout unsurveyed watersheds within the parks, and they are inventorying and replacing or modifying road culverts that will assist bull trout recovery in Puget Sound.

U.S. Environmental Protection Agency. Growing public awareness and concern for controlling water pollution led to the enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act (33 USC 1251 *et seq*.). The Clean Water Act established the basic structure for regulating discharges of pollutants into the waters of the United States. This Act gave the U.S. Environmental Protection Agency the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. This Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. As a requirement of section 303(d) of the Clean Water Act, a list of impaired waters must be prepared by each State and approved by the U.S.

Environmental Protection Agency for all waterbodies that do not fully support their beneficial uses (see, *e.g*., Appendix 2). The Clean Water Act also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution.

Under the Clean Water Act, the U.S. Environmental Protection Agency has authority over approval of all State water quality standards. Because many Pacific Northwest salmonid species are listed as threatened or endangered under the Endangered Species Act, the U.S. Environmental Protection Agency must consult with us and NOAA Fisheries to insure that State or Tribal water quality standards are not likely to jeopardize the continued existence of these listed fish. The U.S. Environmental Protection Agency has developed guidance to assist States and Tribes adopt temperature water quality standards that the Environmental Protection Agency can approve consistent with its obligations under the Clean Water Act and Endangered Species Act (USEPA 2003).

Natural Resources Conservation Service. The Natural Resources Conservation Service works to assist private landowners with conserving their soil, water, and other natural resources. Local, State and Federal agencies and policymakers also rely on the expertise of the Natural Resources Conservation Service for technical assistance with best management practices for conserving natural resources. Most work is done with local partners, such as County Conservation Districts. The Wildlife Habitats Incentives Program, Environmental Quality Incentives Program, and other grants assist private landowner riparian habitat protection and management actions. The Environmental Quality Incentives Program is a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. The Wildlife Habitats Incentives Program is also a voluntary program aimed at working with people who want to develop and improve wildlife habitat (including aquatic areas) on private land.

NOAA Fisheries' Recovery Actions for Puget Sound Chinook. In March 1999, NOAA Fisheries listed the Puget Sound Chinook salmon and Hood Canal summer-run chum salmon Evolutionarily Significant Units as threatened under the Endangered Species Act. These two evolutionarily significant units overlap with the Coastal-Puget Sound Distinct Population Segment of bull trout.

As part of the recovery planning process for Chinook salmon, NOAA Fisheries has issued guidance for the technical development of recovery plans (NMFS, *in litt*. 2000). The framework for salmon and steelhead recovery plan development is divided into distinct geographic areas, or domains, which may contain multiple evolutionarily significant units. Recovery plans for listed salmon and steelhead will contain the same basic elements as mandated by the Endangered Species Act, and include: 1) objective, measurable criteria for gauging recovery; 2) a description of site-specific management actions necessary to achieve recovery; and 3) estimates of the cost and time necessary to carry out recovery actions.

In the Puget Sound Region, NOAA Fisheries is developing a Chinook salmon and summer-run chum salmon recovery plan through a collaborative regional approach, the Shared Strategy for Puget Sound (described in detail later in this section). It is anticipated that many of the habitat recovery actions developed for Chinook salmon will provide conservation benefits to bull trout and in some cases possibly meet their conservation needs (*e.g.*, Chinook salmon recovery actions in mainstem river reaches). However, bull trout will require greater habitat protection and restoration measures in some locations due to their cold water requirements, greater sensitivity to habitat degradation, and use of habitats outside of areas occupied by Chinook salmon. As a participant in the Shared Strategy effort, we will coordinate the implementation of the recovery actions identified in the Puget Sound and Olympic Peninsula Management Unit recovery plans with salmon measures to avoid duplication of effort and to maximize the use of available resources, as well as identify actions necessary for bull trout that are above and beyond what maybe necessary for Chinook salmon recovery.

<u>Native American Tribal Activities</u>

The Tribes within the Puget Sound region are fisheries co-managers along with the Washington Department of Fish and Wildlife, and have an active role in managing the fisheries resource, including monitoring abundances and conserving and restoring salmonid habitats. Their efforts include outmigration sampling, adult and juvenile surveys, research, habitat restoration, and biological and physical monitoring of salmonid watersheds. Most Tribal governments in the Puget Sound region have active natural resource or fisheries departments with technical staff working on collaborative projects with Federal, State, and local entities. A number of Puget Sound Tribes participate in ongoing collaborative regional recovery efforts such as general resource protection, the Shared Strategy for Puget Sound, and in more localized watershed efforts such as the Habitat Limiting Factors analyses under State of Washington House Bill 2496.

Shared Strategy for Puget Sound

In October of 1999, over 150 leaders on salmon issues from throughout Puget Sound gathered in Port Ludlow, Washington, to discuss the region's growing salmon crisis. At this meeting a group representing Tribes, Federal, State, and local governments agreed to develop a Shared Strategy to facilitate a coordinated regional approach to salmonid recovery. The Strategy includes developing a collaborative recovery plan for the region that is guided by clear goals and meets the broad interests for salmon and bull trout in Puget Sound. The Strategy also includes establishing an organizational structure to link recovery efforts, completing a regional recovery plan, guiding its implementation, and identifying and supporting important ongoing near-term efforts to protect Puget Sound salmon and bull trout (Shared Strategy 2002). The Shared Strategy is an effort to engage local citizens, Tribes, technical experts and policymakers to build a practical, cost-effective recovery plan endorsed by the people living and working in the watersheds of the Puget Sound region.

As an ongoing participant and partner in the Shared Strategy, we believe this effort can contribute to the successful implementation of many of the recovery actions identified in the recovery plans for bull trout in the Puget Sound and Olympic Peninsula Management Units. The Puget Sound bull trout recovery team believes the watershed-based planning efforts conducted under the Shared Strategy can help further develop and refine certain site specific recovery actions identified for core areas in the Puget Sound Management Unit, and has referred to those efforts in the "recovery measures narrative" where appropriate.

Puget Sound Nearshore Ecosystem Restoration Project

In 2000, a reconnaissance study conducted by the U.S. Army Corps of Engineers concluded that major human modifications along the Puget Sound shoreline have resulted in a significant loss of estuarine and nearshore habitats. The changes in the physical structure of the shorelines have resulted in significant impacts to critical fish and wildlife resources, including habitat that supports all species of salmonids (USACOE and WDFW 2001). The study identified a number of proposed actions that would be key in restoring nearshore habitats to a more natural state. These actions included: providing or improving beach nourishment (accumulation of sand and gravel materials for forming habitat); removing, moving, or modifying artificial structures (*e.g.*, bulkheads, riprap, dikes, tide gates); using alternative shoreline erosion and flooding protection measures that avoid or minimize impacts to natural nearshore processes; and restoring estuaries and nearshore habitats such as eelgrass beds and kelp beds.

With the U.S. Army Corps of Engineers as lead, a cooperative effort to preserve and restore the health of the Puget Sound nearshore has been formed with local sponsors that include State and other Federal agencies, Tribes, local governments, industries, and environmental organizations. This long-term effort is currently in the feasibility study phase, which evaluates the factors that are causing habitat to decline and pollution to accumulate in the Puget Sound Basin; formulates, evaluates, and screens potential solution to these factors; and recommends a series of actions and restoration projects. Currently, restoration project engineering and design is projected to begin by 2006, and project construction is targeted for 2009. A companion Corps of Engineers construction authority, the Puget Sound and Adjacent Waters Initiative, was authorized to receive first year funds in 2003. The initiative is a construction authority for restoration projects in the Puget Sound Basin.

Canadian Government Activities

Bull trout are currently a “Blue Listed” species by the British Columbia government, and as such receive certain protections from land management activities including timber harvest. Fishing regulations were implemented in 1989 that have reduced the retention limit of bull trout from eight per day (with two fish allowed over 500 millimeters (19.7 inches)) to four per day (with 1 fish allowed over 500 millimeters) in the Lower Mainland Region. Evaluation of the need to further reduce retention limits and/or implement gear restrictions (single barbless hook/bait ban) for bull trout in Chilliwack Lake is ongoing (Jesson, pers. comm. 2002a). Researchers in British Columbia are currently working on a collaborative research project with Seattle City Light to improve our understanding of the Upper Skagit River transboundary populations (Connor and Jesson, *in litt*. 2002). The study is investigating migratory movements, defining spawning areas, and assessing population abundance of bull trout within the Upper Skagit core area and the upper Skagit River system in British Columbia.

STRATEGY FOR RECOVERY

Bull trout have specific ecological requirements and depend upon an interconnected network of complex habitats to support multiple life history forms and facilitate the potential for occasional dispersal between local populations to maintain gene flow and genetic variability. In order to effectively address the needs of this wide-ranging species and the varying threats it faces, as well as incorporate the needs and concerns of the numerous local interest groups involved in its recovery, we have subdivided the Coastal-Puget Sound Distinct Population Segment into two management units, the Puget Sound and the Olympic Peninsula. Within each management unit, recovery will be based on the concept of functional “core areas.” A core area represents the combination of both a core population (*i.e.*, one or more local populations of bull trout inhabiting a core habitat) and core habitat (*i.e.*, habitat that could supply all the necessary elements for the long-term security of bull trout, including for both spawning and rearing, as well as for foraging, migrating, and overwintering) and constitutes the basic unit upon which to gauge recovery.

In the Puget Sound Management Unit, the recovery team identified 8 core areas, with a total of 58 local populations and 3 potential local populations distributed among them (Table 6). The number of local populations includes those stream complexes for which the presence of bull trout spawning and rearing is either known or has been determined through professional judgement as highly likely. As more fish distribution and abundance information is collected, the number of local populations identified will likely increase.

The recovery team also identified “potential” local populations for some core areas. A potential local population may be defined as either a local population that likely exists but has not been adequately documented, or as a local population that does not currently exist but is likely to develop in the foreseeable future. The development of a local population is likely to occur if spawning habitat or connectivity is restored in that area or if bull trout recolonize or are reintroduced in the area. Potential local populations identified in this plan are considered necessary for recovery.

Ensuring the long-term persistence of extant local populations, especially those exhibiting the anadromous life history, is key to supporting self-sustaining core areas of bull trout within the Coastal-Puget Sound Distinct Population Segment. In the coterminous United States, anadromous bull trout are found only within this population segment. In addition to their unique life history, anadromous forms are important because they provide an opportunity for core populations to exchange genetic material and hence increase the diversity and stability of the overall distinct population segment. Presumably this diversity reduces the risk of extinction of the distinct population segment. Large anadromous bull trout also have higher fecundity than the resident and fluvial forms and use a greater diversity of spawning and foraging habitats, which further contributes to population diversity and lowers the risk of extinction. All migratory life history forms require intact spawning and rearing habitat connected to adequate foraging, migration, and overwintering habitat. For anadromous bull trout, these required habitats span the whole watershed, from headwater tributaries to the estuary and adjacent marine nearshore habitat, as well as freshwater systems outside their natal watershed.

Table 6. List of bull trout local populations and potential local populations by core area in the Puget Sound Management Unit.

CORE AREA	LOCAL POPULATION	POTENTIAL LOCAL POPULATION
Chilliwack	Little Chilliwack River	
	Upper Chilliwack River	
	Selesia Creek (British Columbia and U.S.)	
	Depot Creek (British Columbia and U.S.?)	
	Airplane Creek (British Columbia)	
	Borden Creek (British Columbia)	
	Centre Creek (British Columbia)	
	Foley Creek (British Columbia)	
	Nesakwatch Creek (British Columbia)	
	Paleface Creek (British Columbia)	
Nooksack	Lower Canyon Creek	
	Glacier Creek	
	Lower Middle Fork Nooksack River	
	Upper Middle Fork Nooksack River	
	Lower North Fork Nooksack River	
	Middle North Fork Nooksack River	
	Upper North Fork Nooksack River	
	Upper South Fork Nooksack River	
	Lower South Fork Nooksack River	
	Wanlick Creek	
Lower Skagit	Bacon Creek	Sulphur Creek (Lake Shannon)
	Baker Lake	Stetattle Creek (Gorge Lake)
	Buck Creek	
	Cascade River	
	South Fork Cascade River	

Table 6. List of bull trout local populations and potential local populations by core area in the Puget Sound Management Unit.

CORE AREA	LOCAL POPULATION	POTENTIAL LOCAL POPULATION
	Downey Creek	
	Goodell Creek	
	Illabot Creek	
	Lime Creek	
	Milk Creek	
	Newhalem Creek	
	Forks of Sauk River	
	Upper South Fork Sauk River	
	Straight Creek	
	Upper Suiattle River	
	Sulphur Creek	
	Tenas Creek	
	Lower White Chuck River	
	Upper White Chuck River	
Upper Skagit	Big Beaver Creek	Deer Creek (Diablo Lake)
	Little Beaver Creek	
	Lightning Creek	
	Panther Creek	
	Pierce Creek	
	Ruby Creek (includes Granite and Canyon Creeks)	
	Silver Creek	
	Thunder Creek (Diablo Lake)	
	Skagit River (British Columbia)	
	East Fork Skagit River (British Columbia)	
	Klesilkwa River (British Columbia)	
	Nepopekum Creek (British Columbia)	

Table 6. List of bull trout local populations and potential local populations by core area in the Puget Sound Management Unit.

CORE AREA	LOCAL POPULATION	POTENTIAL LOCAL POPULATION
	Skaist River (British Columbia)	
	Sumallo River (British Columbia)	
Stillaguamish	Upper Deer Creek	
	South Fork Canyon Creek	
	North Fork Stillaguamish River	
	South Fork Stillaguamish River	
Snohomish-Skykomish	North Fork Skykomish River	
	South Fork Skykomish River	
	Salmon Creek	
	Troublesome Creek	
Chester Morse Lake	Boulder Creek	Shotgun Creek
	Upper Cedar River	
	Rex River	
	Rack Creek	
Puyallup	Carbon River	Clearwater River
	Greenwater River	
	Upper Puyallup and Mowich Rivers	
	Upper White River	
	West Fork White River	

Recovery Goals and Objectives

The goal of the bull trout recovery plan is to **ensure the long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the species' native range so that the species can be delisted.** To accomplish the goal, recovery objectives addressing distribution, abundance, habitat and genetics were identified.

The recovery objectives for the Puget Sound Management Unit are as follows:

- Maintain the current distribution of bull trout, particularly anadromous forms, and restore migratory life history forms in some of the previously occupied areas within the Puget Sound Management Unit.

- Maintain stable or increasing trends in abundance of bull trout in the Puget Sound Management Unit.

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, with an emphasis on anadromy.

- Conserve genetic diversity and provide opportunity for genetic exchange to conserve migratory life history forms.

Rieman and McIntyre (1993) and Rieman and Allendorf (2001) evaluated the bull trout population numbers and habitat thresholds necessary for the long-term viability of the species. They identified four key elements, and the characteristics of each of those elements, for consideration when evaluating the viability of bull trout populations. These four elements are: (1) the number of local populations; (2) adult abundance (defined as the number of spawning fish present in a core area in a given year); (3) productivity, or the reproductive rate of the population (as measured by population trend and variability); and (4) connectivity (as represented by the presence of the migratory life history form and functional habitat). For each element, the Puget Sound Recovery Team classified bull trout populations into relative risk categories based on the best available data and the professional judgement of the team.

The Puget Sound Recovery Team evaluated these key elements to produce target levels for each under a potential recovered condition. The evaluation of these elements under a recovered condition assumed that the actions identified within this plan had been implemented. The recovery targets for the Puget Sound Management Unit reflect: (1) the stated objectives for the management unit; (2) the evaluation of each population element under both current and recovered conditions; and (3) consideration of current and recovered habitat characteristics within the management unit. These recovery targets are subject to refinement in the future as more detailed information on bull trout population dynamics becomes available. Given the limited information currently available on bull trout, both the level of adult abundance and the number of local populations needed to lessen the risk of extinction should be viewed as best estimates at this time.

This approach to developing recovery criteria acknowledges that the status of populations in some core areas may remain short of the ideals described by conservation biology theory. Some core areas may be limited by natural attributes or by patch size and may always remain at a relatively high risk of extinction. Because of the limited availability of data for the Puget Sound Management Unit, the recovery team relied heavily on the professional judgement of its members.

Local Populations. Metapopulation theory is important to consider in bull trout recovery. A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994). The distribution and interconnection of multiple local populations throughout a watershed provide a mechanism for spreading risk from stochastic[†] events and allows for potential recolonization in the event of local extirpations. In part, the distribution of local populations in such a manner is an indicator of a functioning core area. Based in part on guidance from Rieman and McIntyre (1993), bull trout core areas with fewer than 5 local populations are at increased risk of local extirpation, core areas with between 5 and 10 local populations are at intermediate risk, and core areas with more than 10 interconnected local populations are at diminished risk.

In the Lower Skagit core area there are currently 19 known local populations. Not only are the local populations numerous, they are also well distributed throughout the core area. Based on the above guidance, the Lower Skagit core area is at diminished risk of adverse effects from stochastic events. In the Upper Skagit core area there are eight local populations currently identified and these are well distributed within the core area. By including only the local populations within the United States in this risk evaluation, the Upper Skagit core area is considered to be at an intermediate risk. However, there are believed to be at least six additional local populations in British Columbia, which are functionally part of the core area. If these are included in our risk evaluation, the Upper Skagit core area would be at a diminished risk of adverse effects from stochastic events[4]. Two regions within these core areas remain a concern, Diablo Lake (Upper Skagit), which currently supports a single local population, and Gorge Lake (Lower Skagit core area), which has one potential local population. If connectivity cannot be restored to these two lake systems, the establishment of additional local populations should be a high priority for these isolated areas where possible. For Diablo Lake, Deer Creek and other tributaries such as Colonial Creek should be further evaluated as to their potential for supporting a local population. It is currently believed that no additional local populations, other than Stetattle Creek, can likely be established in the Gorge Lake system.

The Chilliwack, Nooksack, and Puyallup core areas are considered to be at intermediate risk given the current number of local populations that have been identified. Although generally well distributed, they each support fewer than 10 local populations. There are only three local populations identified for the

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The degree of risk was evaluated separately for the United States portion of this core area, since from an administrative standpoint our jurisdiction technically extends only to those local populations within the United States border. From a biological standpoint, however, these populations are functionally interconnected with the populations in Canada, so the true biological risk is diminished when considered at the level of the core area as a whole. The Chilliwack core area, also shared with Canada, was evaluated in a similar manner.

Chilliwack core area; however, by including the seven local populations identified in British Columbia in our risk evaluation, this core area would functionally be at diminished risk from stochastic events. In the Nooksack core area, the known spawning areas within identified local populations appear to be small in size and dispersed. In the Puyallup core area, the known spawning areas within identified local populations are few in number and not widespread. The Clearwater River system should be further evaluated as to its potential for supporting an additional local population within this system.

The Stillaguamish, Snohomish-Skykomish, and Chester Morse Lake core areas are considered to be at an increased risk of adverse effects from stochastic events. The local populations are generally well distributed throughout these three core areas, however, currently identified local populations have few known spawning areas. The majority of migratory individuals spawn in one local population (North Fork Skykomish River) in the Snohomish-Skykomish core area, placing it in a much more vulnerable state. Recent establishment of the population above Sunset Falls on the South Fork Skykomish River has greatly increased the spawning distribution within the core area, reducing the overall risk. Chester Morse Lake is the smallest core area within the management unit, with the majority of spawning occurring in two local populations. Spawning distribution is generally concentrated within a short river reach in these two local populations, increasing their vulnerability to stochastic events. Recent monitoring efforts for these two local populations suggest they are relatively resilient to stochastic pressures (*e.g.*, major flood events). However, the much smaller local populations identified within the Chester Morse Lake core area need to be maintained and the establishment of additional local populations should be assessed to reduce the overall risk to the core area.

Adult Abundance. The recovered abundance levels in the Puget Sound Management Unit were determined by considering theoretical estimates of effective population size[†], historical census information, and the professional judgement of recovery team members. In general terms, the effective population size is the functional size of the population, from a genetic standpoint, based on the numbers of individuals that successfully breed and the distribution of offspring among individuals. The effective population size may be substantially smaller than the census population size. Effective population size is an important theoretical construct in conservation biology, since genetic variability may be lost from a population with high numbers of individuals if the effective population size is low (Kimura and Crow 1963; Franklin 1980). The concept of effective population size allows us to predict potential future losses of genetic variation within a population due to small population sizes and genetic drift (see Appendix 3).

For the purposes of recovery planning, we used the number of adult bull trout that successfully spawn annually as a measure of effective population size. Based on standardized theoretical equations (Crow and Kimura 1970), guidelines have been established for maintaining minimum effective population sizes for conservation purposes. Effective population sizes of greater than 50 adults are necessary to prevent inbreeding depression and a potential decrease in viability or reproductive fitness of a population (Franklin 1980). To minimize the loss of genetic variation due to genetic drift and to maintain constant genetic variance within a population, an effective population size of at least 500 is recommended (Franklin 1980; Soulé 1980; Lande 1988). Effective population sizes required to maintain long-term genetic variation that can serve as a reservoir for future adaptations in response to natural selection and changing environmental conditions are discussed in Appendix 3.

For bull trout, Rieman and Allendorf (2001) estimated that a minimum number of 50 to 100 spawners per year is needed to minimize potential inbreeding effects within a local population. In addition, a minimum population size of between 500 and 1,000 adults is needed to minimize the deleterious effects of genetic drift at the level of a core area.

For the purposes of bull trout recovery planning, abundance levels were conservatively evaluated at the local population and core area levels. Local populations containing fewer than 100 spawning adults per year were classified as at risk from inbreeding depression. Bull trout core areas containing fewer than 1,000 spawning adults per year were classified as at risk from genetic drift.

Detailed abundance estimates for the Puget Sound Management Unit are currently not available due to limited and nonrepresentative data. Similarly, detailed abundance estimates are not always available at the local population scale. However, the recovery team has provided recovered abundance targets for each core area, based on available data sets, habitat considerations, the population guidance discussed above, and best professional judgement.

The recovery team believes the Lower Skagit core area has the greatest abundance of bull trout within the management unit. The adult abundance of bull trout in the Lower Skagit core area is thought to exceed several thousand individuals based on the number of local populations, estimates of abundance in local populations, and redd counts in the South Fork Sauk River spawner index reach. This core area is currently not considered at risk from genetic drift. Although some local populations within the Lower Skagit core area are believed to support fewer than 100 adults and therefore may be at risk from inbreeding depression, the majority of local populations within the core area are at or above this level.

In the Upper Skagit core area, including those portions of the drainage within British Columbia that are functionally part of the core area, the adult abundance likely exceeds 1,000 spawners. This core area is currently not considered to be at risk from genetic drift. There are likely at least 100 adult spawners in both the Ruby Creek and Lightning Creek local populations based on observations of staging adults and the amount of intact spawning habitat presumed available in these systems. Adult abundance in the remaining local populations within the core area are currently unknown, so the risk from inbreeding for these areas is currently undetermined.

In the Chilliwack core area, including those portions of the drainage within British Columbia that are functionally part of the core area, the adult abundance likely exceeds 1,000 spawners. The core area is currently not considered to be at risk from genetic drift. Adult abundance in the Chilliwack River local population is likely near or in excess of 100 spawners based on preliminary angler catch data in Chilliwack Lake and the near pristine habitat available in North Cascades National Park. Adult abundance in the remaining local populations within the core area are currently unknown, so the risk from inbreeding for these areas is currently undetermined.

Currently the adult abundance of bull trout in each of the Nooksack, Stillaguamish, and Puyallup core areas is likely fewer than 1,000 spawners. Although current adult abundance estimates are lacking for most local populations within these core areas, the majority of local populations likely have fewer than 100 adults each based on the relatively low numbers of migratory adults observed returning to these core areas. In the Nooksack core area, the Glacier Creek local population is likely near or in excess of 100 adult spawners based on incidental redd counts and available spawning habitats. It is possible that 100 adult spawners may also currently exist within the Upper North Fork Nooksack River local population based on the number of persistent small numbers of spawning adults observed in tributaries and the available side channel habitat in this section of the North Fork. Although the glacial nature of this system limits comprehensive adult counts, bull trout spawning has been documented in some of these side channel habitats. In the Stillaguamish core area, only the North Fork Stillaguamish River local population likely meets or exceeds 100 adult spawners based on preliminary adult counts. In the Puyallup core area, current abundance estimates are not available for most local populations. Local populations in the White River system are all likely below 100 adult spawners based on adult counts at the Buckley fish trap. We recognize that these counts may not adequately account for fluvial migrants that might not migrate below the facility, but these counts show that there are few anadromous bull trout returning to local populations in the White River system.

The Snohomish-Skykomish and Chester Morse Lake core areas both likely support between 500 and 1,000 adult spawners, based on the recent redd counts in the North Fork Skykomish River spawning index reach and in the upper Cedar River watershed, respectively. In the Snohomish-Skykomish River core area, the current abundance of the Salmon Creek local population is likely fewer than 100 spawning adults, potentially putting it at an increased risk from inbreeding depression. Although the South Fork Skykomish River local population is currently just below 100 adults, escapement is steadily increasing. In the Chester Morse Lake core area, estimated adult abundance in Boulder Creek and Rack Creek local populations is below 100 adults, potentially placing these local populations at an increased risk from inbreeding depression.

Abundance target levels. To develop recovered abundance targets for core areas, the Puget Sound Recovery Team considered and modified the population guidance presented above. To address inbreeding concerns, the team chose to base local population abundance using the higher value from the 50 to 100 spawners needed to avoid inbreeding depression. The team further recommends that individual minimum local population abundance be set at 200 spawning adults in the Puget Sound Management Unit, given recent information from the Lower Skagit core area indicating that only 50 percent of the adult spawning population are first time spawners (Kraemer, *in litt*. 2003). This minimum abundance provides a buffer against stochastic events, helps ensure diverse age structure among spawners, and helps ensure the expression of diverse life histories within core areas. Available information indicates that many if not most local populations can achieve this abundance, provided adequate habitat conditions are maintained or restored. The team acknowledged that some local populations may not be able to achieve this ideal minimum abundance, while others will likely reach much higher abundances due to natural differences in habitat capacity among the local populations. However, we believe 200 spawners should be the current basis for setting recovered abundance targets for each core area.

To develop a recovered abundance target for each core area, two factors were considered. The first factor was the minimum number of adult spawners needed to avoid the deleterious effects from genetic drift. The team selected 1,000 spawning adults as that minimum number, based on the high value of the suggested range from 500 to 1,000 spawning adults. In addition, the total number of local populations in the core area was considered. Since each local population minimum was set at 200 spawning adults, the recovered abundance target number of spawning adults should be at least 200 times the number of local populations within the core area. The team recommended that the recovered abundance target for each core area be set at either the product of the number of local populations in the core area and the minimum local population abundance of at least 200 spawning adults (number of local populations × 200), or a simple minimum of

1,000 spawning adults, whichever is greater. Thus core areas with more than five local populations would have recovered abundance target levels of more than 1,000 spawning adults, while those with fewer local populations would have an abundance target set at the minimum level of 1,000 spawning adults (Table 7).

Table 7. Number of current local populations, including those with greater than 100 spawning adults (considered not at risk of inbreeding depression), and summary of target abundance levels of spawning adults necessary to recover migratory bull trout in core areas of the Puget Sound Management Unit (see text for derivation of abundance targets).

Core Area	Estimated Existing Number of Local Populations (United States)	Estimated Existing Number of Local Populations with >100 adults (United States)	Recovered Minimum Number of Local Populations with >100 adults (United States)	Recovered Minimum Core Area Adult Abundance Targets
Chilliwack	3	1	3	600 [b]
Nooksack	10	1	9	2,000
Lower Skagit	19	14	14	3,800
Upper Skagit	7[a]	2	5	1,400 [b]
Stillaguamish	4	1	4	1,000
Snohomish-Skykomish	3[a]	1	3	500[c]
Chester Morse Lake	4	2	2	500[c]
Puyallup	5	1	5	1,000

a. Number does not include local populations with primarily resident forms.
b. Target does not include those local populations occurring entirely within British Columbia.
c. Target adjusted to reflect natural habitat limitations.

In the Chilliwack core area, the abundance target reflects only those local populations within the United States portion of this river system. Based on the number of local populations identified within British Columbia, the abundance target for the complete Chilliwack River system would be at least

1,200 adult spawners. In the Snohomish-Skykomish and Chester Morse Lake core areas, some downward adjustment was applied to the recovered minimum number, since these core areas historically had habitats that were unlikely to consistently support as many as 1,000 adult spawners annually. It should be noted, however, that recent redd counts in these 2 core areas indicate that the number of spawners likely approaches or exceeds 1,000 adults in some years.

Productivity. A stable or increasing population is a key criterion for recovery. Measures of the trend of a population (the tendency to increase, decrease, or remain stable) include population growth rate or productivity. Estimates of population growth rate (*i.e.*, productivity over the entire life cycle) that indicate a population is consistently failing to replace itself ($\lambda < 1.0$) indicate an increased risk of extinction. Therefore, the reproductive rate should indicate that the population is at least replacing itself, or growing ($\lambda \geq 1.0$) to be considered recovered.

Since estimates of the total population size are rarely available, the productivity or population growth rate is usually estimated from temporal trends in indices of abundance at a particular life stage. For example, redd counts are often used as an index of a spawning adult population. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For instance, a downward trend in an abundance indicator may signal the need for increased protection, regardless of the actual size of the population. A population that is below recovered abundance levels, but that is moving toward recovery, would be expected to exhibit an increasing trend in the indicator.

The population growth rate is an indicator of probability of extinction. This probability cannot be measured directly, but it can be estimated as the consequence of the population growth rate and the variability in that rate. For a population to be considered viable, its natural productivity should be sufficient for the population to replace itself from generation to generation. Evaluations of population status will also have to take into account uncertainty in estimates of population growth rate or productivity. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Because the trend status is unknown due to lack of data, bull trout populations in the Chilliwack, Nooksack, Upper Skagit, Stillaguamish, Chester Morse Lake, and Puyallup core areas are considered at an increased risk until sufficient information is collected to properly assess their productivity. Significant increases in abundance for the past three years in the Chester Morse Lake core area, suggest that this core area is at a lower risk. However, additional years of trend data are needed to confirm this. In contrast, bull trout in the Lower Skagit and the Snohomish-Skykomish core areas are at a diminished threat due to long-term redd counts that indicate increasing population trends.

Connectivity. The presence of the migratory life history form within the Puget Sound Management Unit was used as an indicator of the functional connectivity of the unit. If the migratory life form was absent, or if the migratory form is present but local populations lack connectivity, the core area was considered to be at increased risk. If the migratory life form persists in at least some local populations, with partial ability to connect with other local populations, the core area was judged to be at intermediate risk. Finally, if the migratory life form was present in all or nearly all local populations, and had the ability to connect with other local populations, the core area was considered to be at diminished risk.

Migratory bull trout likely persist in most local populations in the Chilliwack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, and Chester Morse Lake core areas, so these areas are considered to be at a diminished risk. Although the Lower and Upper Skagit core areas are generally considered to be at diminished risk, there are three areas within the Skagit River that have very poor connectivity with other local populations and remain a concern. These are Diablo Lake (Upper Skagit) which supports a single local population of migratory bull trout, and Gorge Lake (Lower Skagit core area) which has one potential local population. If connectivity between the Diablo Lake system and the rest of the Upper Skagit core area cannot be adequately restored at Ross Dam, the establishment of additional local populations will likely be needed to help ensure that the Diablo Lake system can persist as an independent core area. Bull trout within the Gorge Lake system are generally isolated from other local populations except for potential one way migration during spill events. If connectivity cannot be adequately restored at Gorge Dam, establishment of the Stetattle Creek potential local population will be critical if these bull trout are determined to be genetically unique. Current connectivity of the Baker Lake local population with the rest of the Lower Skagit core area is also a concern. To ensure persistence of this local population, and to maintain overall distribution within the core area, further evaluation of providing improved connectivity (two-way fish passage) at the Baker Lake Hydroelectric complex is required. In the Nooksack core area, there is connectivity among most local populations, with the exception of the Middle Fork Nooksack River (City of Bellingham Diversion). Based on poor fish passage in the Middle Fork Nooksack River and the presence of road culvert barriers in several local populations, this core area is believed to be at intermediate risk with respect to connectivity. Although migratory bull trout may persist in some local populations in the Puyallup core area, and although connectivity between the upper Puyallup and Mowich Rivers local population with other local populations has been recently improved, there have been very low numbers of migratory fish passing at the Buckley Diversion, placing this core area at an intermediate risk. The low abundance of the migratory life history forms limits the possibility for genetic exchange and local population reestablishment.

Recovery Targets for the Puget Sound Management Unit

As noted in Part I of this plan, recovery and delisting can only occur at the level of the listed entity. Consideration of delisting will depend upon attainment of the recovery criteria for bull trout across their range within the coterminous United States, as currently listed, or at the level of the distinct population segment as a whole should that population segment be found to meet the definition of a distinct population segment under a formal regulatory rulemaking process. For the purposes of recovery planning, we have defined recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment as currently delineated. Although this population segment has been divided into two management units, these units are not eligible to be considered separately for delisting (a management unit is not a listed entity). We have therefore set recovery targets for each of the management units within the Coastal-Puget Sound Distinct Population Segment. These recovery targets reflect the recovery criteria measurement parameters identified for the entire distinct population segment, and reflect our best estimation as to how the recovery criteria can be met, working on recovery at the level of the management unit. We recognize that different configurations may be feasible and we welcome suggestions on alternative targets which can achieve recovery at the level of the distinct population segment.

This recovery plan presents recovery targets for the Puget Sound Management Unit only; recovery targets for the Olympia Peninsula Management Unit are presented separately in Volume II of the recovery plan for the Coastal-Puget Sound Distinct Population Segment of bull trout.

Recovery targets for the Puget Sound Management Unit:

1. **Maintain or expand the current distribution of bull trout in the eight identified core areas[5].** The 57 currently identified local populations (Chilliwack (3), Nooksack (10), Lower Skagit (19), Upper Skagit (8), Stillaguamish (4), Snohomish-Skykomish (4), Chester Morse Lake (4), and Puyallup (5)) will be used as a measure of broadly distributed spawning and rearing habitat within these core areas. In addition, distribution within the five identified potential local populations should be confirmed or restored.

   As noted above, the migratory life history form currently comprises the majority of bull trout in these core areas.

   For recovery to occur, the distribution of these migratory local populations should be maintained, while abundance is increased. However, it should be noted that the number and location of existing local populations is used here as a rough surrogate to reflect what the overall distribution in a core area should look like in the future. In accordance with metapopulation dynamics, it is possible that there may be natural shifts in the numbers or locations of local populations that contribute to the

[5]This criterion applies only to United States waters within this management unit.

function of the metapopulation as a whole. We anticipate that some local populations could be extirpated, others could be established, others could be subdivided with new genetics information, and the distinction between others could fade as barriers to movement are addressed. This criterion must therefore be applied with enough flexibility to allow for adaptive changes in the list of local populations (both additions and subtractions), based on best available science, as additional information concerning population and genetic inventory is gathered. The designation of local populations is based on survey data and the professional judgement of Puget Sound Recovery Team members. Further genetic studies are needed in order to more accurately delineate local populations and quantify spawning site fidelity and straying rates. Additional local populations may be added to this total as additional information is gathered in areas outside the currently designated core areas for this management unit, or if new data indicates currently identified local populations should be further subdivided.

We recognize that stochastic events or deterministic processes already occurring could negatively affect distribution in some cases. The significance of such losses in distribution in ultimately determining whether or not distribution criteria have been met needs to be judged on a case-by-case basis. Maintaining the distribution of bull trout in the British Columbia portion of the Chilliwack (seven local populations) and Upper Skagit core areas (seven local populations) is equally essential, although not covered under the jurisdiction of this plan.

2. **Achieve minimum estimated abundance of at least 10,800 adult bull trout spawners among all core areas in the Puget Sound Management Unit. In each of the core areas, the total adult bull trout abundance, distributed among local populations, typically must exceed 1,000 fish.** Recovered abundance targets for the Chilliwack (600), Nooksack (2,000), Lower Skagit (3,800), Upper Skagit (1,400), Stillaguamish (1,000), Snohomish-Skykomish (500), Chester Morse Lake (500), and Puyallup

(1,000) core areas were derived using a combination of available data sets, the population guidance discussed earlier, the professional judgement of the recovery team, and estimation of the productive capacity of identified local populations. Resident life history forms are not included in this estimate, but are considered a research need. As more data is collected, recovered population estimates will be revised to more accurately reflect both the migratory and resident life history components. The recovery team has initially set abundance targets conservatively if there was limited available information. These will likely be revised as new information becomes available.

3. **Restore adult bull trout to exhibit stable or increasing trends in abundance at or above the recovered abundance target level within the core areas in the Puget Sound Management Unit, based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data. (Note: generation time varies with demographic variables such as age at maturity, fecundity, frequency of spawning, and longevity, but typically falls in the range of 5 to 8 years for a single bull trout generation).** Productivity criteria are met when adult bull trout exhibit a stable or increasing trend for at least two generations at or above the recovered abundance target level within the Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse, and Puyallup Core Areas. The development of a standardized monitoring and evaluation program which would accurately describe trends in bull trout abundance is identified as a priority research need. As part of the overall recovery effort, we will take the lead in addressing this research need by forming a multi-agency technical team to develop protocols necessary to evaluate trends in bull trout populations.

4. **Restore connectivity by identifying and addressing specific existing and potential barriers to bull trout movement in the Puget Sound Management Unit.** Connectivity criteria will be met when intact migratory corridors are present among all local populations within each core area, thus providing opportunity for genetic exchange and life history diversity. Several man-made barriers to bull trout migration exist within

the management unit, and this recovery plan recommends actions to identify, assess, and reduce barriers to bull trout passage. Although achieving criteria 1 through 3 is expected to depend on providing passage at barriers (including barriers due to physical obstructions, unsuitable habitat, and water quality) throughout all core areas in the management unit, the intent of this criterion is to note specific barriers to correct or actions that must be performed to achieve recovery.

Known passage barriers include the Bellingham Diversion (Nooksack core area), Gorge Dam (Lower Skagit core area), and Ross Dam (Upper Skagit core area). Connectivity must be restored above the Bellingham Diversion to allow the Upper Middle Fork Nooksack River local population to fully express the fluvial and/or anadromous migratory life histories and to provide access to primary foraging, migration, and overwintering habitats (both freshwater and marine). Connectivity is also necessary to reduce the risk of local extirpation and allow potential genetic exchange with the rest of the Nooksack core area. The need for passage must be evaluated at Gorge and Ross Dams. Should passage be determined unfeasible at Gorge and Ross Dams, additional recovery measures may be needed to maintain persistence of the local population (Thunder Creek in Diablo Lake) and potential local population (Stetattle Creek in Gorge Lake) isolated by these facilities. Passage improvement must be addressed at the Baker River dams (Lower Skagit core area), and at the Electron and Buckley Diversions (Puyallup core area). Assess effectiveness of passage for bull trout at the Tacoma Headworks diversion dam and Howard Hansen Dam (Lower Green River foraging, migration, and overwintering habitat) once fish passage facilities are completed at both dams, as part of evaluating the potential to establish or reestablish an additional core area in south Puget Sound. An additional core area in this region would help secure distribution in the southern part of the management unit. In the management unit as a whole, any proposed hydropower facilities or diversions must provide adequate two-way fish passage for all impacted bull trout life stages.

The development of criteria and specific actions necessary for remaining connectivity needs will be implemented as the necessary information becomes available. Actions that will be needed following the identification and assessment of specific problem areas include eliminating or minimizing entrainment at diversions and ditches (actions 1.2.1), providing adequate fish passage around diversions and dams (1.2.2), eliminating culvert barriers (action 1.2.3), and improving instream flows (1.1.11 and 1.4.2). Substantial gains in reconnecting fragmented habitat may be achieved in Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas by restoring passage over or around many types of barriers that are typically located on smaller streams, including road crossings, culverts, and water diversions.

The known barriers are listed above and in the Recovery Measures Narrative section of this plan, but many (*e.g.*, culverts) have not yet been identified or have not yet been addressed. However, they are collectively important to recovery. Actions to identify and assess barriers to bull trout passage are recommended in this recovery plan and appropriate actions must be implemented. A list of all such artificial barriers should be prepared in the first 5 years of implementation, and prioritized so that highest priority is directed towards providing access to potential spawning and rearing habitat in local populations, followed by providing access to additional foraging habitats. Substantial progress must be made in providing passage at a significant number of these sites to meet the bull trout recovery targets for connectivity.

Recovery targets for the Puget Sound Management Unit were established to assess whether recovery actions are resulting in the recovery of bull trout. The Puget Sound Recovery Team expects that the recovery process will be dynamic and will be refined as more information becomes available.

Research Needs

Based on the best scientific information available, the Puget Sound Recovery Team has identified recovery targets and actions necessary for recovery of bull trout within the management unit. However, the recovery team recognizes that uncertainties exist regarding bull trout population abundance, distribution, and actions needed to achieve recovery. The recovery team feels that if effective management and recovery are to occur, the recovery plan for the Puget Sound Management Unit must be viewed as a “living” document, which will be updated as new information becomes available. The recovery team will rely on adaptive management to guide recovery implementation. Adaptive management is a continuing process of planning, monitoring, evaluating management actions, and research. Adaptive management will involve a broad spectrum of user groups and will lay the framework for decision-making relative to recovery implementation and ultimately the possible revision of recovery targets in this management unit. As a part of this adaptive management approach, the recovery team has identified research needs that are essential within the management unit. The research needs are listed by priority and, where applicable, in order of sequence.

Population Structure. The Puget Sound Recovery Team recommends that studies be initiated to more precisely describe the genetic makeup of bull trout within management unit core areas. This information would be essential for a more complete understanding of bull trout interactions and population dynamics within the management unit. Additional information on population structure would greatly assist in further refining or revising (confirming, splitting, or combining) the currently identified local populations within core areas, and potentially the core areas themselves. This will require a comprehensive and coordinated sampling effort within all identified local populations.

Distribution, Abundance, and Productivity in Core Areas. A high priority goal for the Puget Sound Management Unit is to acquire more complete information on the current distribution and abundance of bull trout within each core area. This effort will require the application of a scientifically accepted protocol such as that described in the draft Protocol for Determining Bull Trout Presence (Peterson *et al.* 2002), which is currently being evaluated by the Western Division of the American Fisheries Society. The American Fisheries Society protocol consists of standardized and statistically rigorous methods for determining the distribution of juvenile bull trout. Other bull trout or fish survey protocols are available and may be considered in this effort. The Washington Department of Fish and Wildlife developed an earlier guide for sampling the distribution and abundance of bull trout (Bonar *et al.* 1997). These or similar protocols will likely require modification for some areas of the Puget Sound Management Unit due to the physical characteristics of some bull trout spawning streams (*e.g.*, larger stream width and depth, high levels of glacial turbidity).

It is critical that representative spawning index reaches or other appropriate surrogates are developed soon for all core areas to adequately monitor changes in population abundance and productivity. Index reaches have only been established for the Lower Skagit, Snohomish-Skykomish, and Chester Morse core areas.

Key Habitat Features Requiring Protection, Restoration, and Enhancement. Additional research is needed to identify key habitat features and limiting factors with greater precision for bull trout in both freshwater and marine habitats to ensure that habitat protection, restoration, and enhancement activities address critical limiting factors. Priorities include identification of key groundwater sources, hyporheic[†] areas, and other cold water refugia; better information on the rates and locations of exposure to and sublethal effects of various environmental contaminants; identification of required water temperature regimes in river reaches used for foraging and migration; and identification of key habitat features in mainstem migratory corridors and overwintering areas.

Marine and Estuarine Habitat Use. Bull trout's complete use of estuarine and marine waters are unknown. The marine and estuarine residency period for bull trout is poorly understood, as are complete habitat preferences and complete foraging requirements. Our current understanding of bull trout estuarine and marine use is based on limited observational data, ongoing research projects, and inferences drawn from work conducted on similar species outside the management unit (*e.g.* Dolly Varden). To adequately protect, conserve, and restore estuarine and marine habitats that can support bull trout, research is needed to determine the species' full range of habitat preferences (*e.g.*, depth, salinity, bottom types, foraging habitats). Available information indicates bull trout use primarily nearshore waters, however this use may be biased due to the limitations of sampling in deeper more offshore locations. Based on a limited amount of diet analysis, we do know that in addition to juvenile salmonids, a number of small marine forage fish species are critical to bull trout in estuarine and marine waters (*i.e.*, surf smelt, sandlance, Pacific herring) (WDFW *et al*. 1997), making the protection of key forage fish habitats critical to the recovery of bull trout. It is critical to determine if there are other species, such as specific invertebrates or other estuarine and marine fish, that are also important forage items either in certain feeding areas or to particular bull trout life stages. It is also crucial to better understand the relationship between these essential prey resources and the habitats which support their production and distribution. The processes which build and sustain nearshore habitats are highly susceptible to human impacts, such as bulkheads and other shoreline armoring, which separate beaches from the bluffs which feed them.

Impacts of Fisheries on Bull Trout. Additional information is needed regarding the extent of incidental mortality of bull trout in State recreational and commercial fisheries and Tribal fisheries. These fisheries may impact the largest fish, and core areas with popular recreational fisheries or important Tribal salmon fisheries may be experiencing significant incidental bull trout mortalities.

Monitoring fishing effort and catch is needed from a representative sample of rivers and marine areas throughout the management unit area. Better estimates of bull trout catches are also needed throughout the year. Catch rates for bull trout may be highest during the summer months, but there is substantially more fishing effort on rivers during the fall and winter salmon and steelhead fisheries.

It is unclear whether there is an impact by recreational anglers during the bull trout spawning period. Many spawning areas are high upstream in watersheds, and access may be difficult during the late fall and winter when conditions are poor for hiking. Staging and spawning areas and the timing of these events should be identified to determine what impact recreational fishing could have on bull trout staging and spawning.

Additional information is needed to assess hooking and handling mortality when bull trout are caught and released. While there is considerable information in the literature regarding catch-and-release mortality for trout, there is very little comparable data for bull trout or Dolly Varden. Mortality rates for bull trout caught and released are needed by gear types (barbed versus barbless hooks, single versus treble hooks, and hook size), water temperatures, and bait versus artificial lures. Differences in handling stress and mortality are also needed for bull trout caught in lakes, especially those caught and released by trolling. In addition, specific mortality rates are needed by life stage (juveniles, prespawners, and postspawners).

Monitoring non-Tribal commercial and Tribal gill-net harvest impacts to bull trout is needed to determine the level of impact on bull trout populations. In addition, research may be needed to develop alternative methods for salmon gill-net fisheries, such as adjusting net mesh sizes and/or duration and placement of nets to minimize accidental capture and incidental mortality of bull trout.

Migratory Timing and Patterns of Anadromous Life History Form. Based primarily on Kraemer's (1994) Skagit River work, it is believed that bull trout juveniles generally migrate to the estuary from March to August with most migration occurring between late April through early June (Lummi Nation, *in litt*. 2003; WDFW, *in litt*. 2003) and then re-enter the river from August through November. Subadults.(fish that are not sexually mature but have already entered marine waters) are thought to move between the lower river and estuary throughout the year, but primarily overwinter in freshwater. Most adult fish are believed to enter the estuary in February and March and leave the estuary between May and June to migrate upstream to their spawning grounds. Although the rough timing of migrations to and from marine waters is known, additional research is needed to more precisely understand peak migration timing of various life stages, determine if this timing is the same for all core areas, and determine migration patterns and migratory routes. Additional efforts are needed to help clarify the extent of marine foraging migrations throughout Puget Sound. Most efforts to date have focused on eastern Puget Sound shorelines, which have helped increase our knowledge of marine distribution of bull trout in parts of this area; however, there are significant gaps in our current understanding of the level and frequency of use along the west and south Puget Sound shorelines, and various island shorelines (*e.g.*, Vashon, Whidbey, San Juans). Although bull trout have been documented moving between major river basins via marine waters, the patterns and extent of these migrations are not well known. Recent efforts in the

Snohomish River have begun to study this behavior more closely (USACOE, *in litt*. 2002). Research should focus on elucidating the marine movements of bull trout from each of the core areas, between core areas, and potential movement to and from areas outside of the Puget Sound Management Unit. It is likely that anadromous populations close to the Canadian border make migrations to coastal streams in British Columbia to forage, but this has not been confirmed. Additional research efforts should be conducted to determine if movements occur between the Puget Sound and Olympic Peninsula Management Units.

Monitoring and Assessment Program. This draft recovery plan is the first step in the planning process for bull trout recovery in the Puget Sound Management Unit. The recovery team identified the need to develop a standardized monitoring and assessment program to more accurately describe the current status of bull trout within the management unit, as well as to identify sampling protocols to allow monitoring of recovery action effectiveness. We will take the lead in developing a comprehensive monitoring approach that will provide guidance and consistency in evaluating bull trout populations. Evaluating implementation and monitoring effectiveness of recommended actions will be an important component in the application of adaptive management in recovery implementation. Monitoring and evaluation of population levels and distribution will be an important component of any adaptive management approach.

Potential Use of the Nisqually and Green Rivers. Although historical accounts indicate a much greater use of the Nisqually and Green River watersheds by bull trout in the past, current use appears to be very limited. Today, low numbers of bull trout appear to use these systems primarily for foraging and potentially overwintering. Given that current abundance and distribution are very limited in the southern portion of the Puget Sound Management Unit, the establishment of an additional spawning population in this area would significantly help reduce the risk of local extirpation and loss in distribution. Although the upper Green River was historically accessible to migratory bull trout, there is no information regarding past bull trout use of the upper watershed. An evaluation of water temperature regime will be critical to determine if bull trout spawning and incubation would be successful in this part of the watershed if passage were restored. Although historical access to the upper Nisqually River watershed remains uncertain, stream temperatures in the upper part of the watershed have a high likelihood of being adequate for successful bull trout spawning and rearing due to their glacial nature. It is currently undetermined whether a small remnant population may still exist somewhere in the upper (and/or perhaps lower) watershed, since stream conditions make fish surveys in this area difficult.

RECOVERY ACTIONS

Structure of the Recovery Measures Narrative Outline

The recovery measures narrative outline consists of a hierarchical listing of actions needed to achieve the recovery of bull trout in the Puget Sound Management Unit. The first tier entries represent general recovery actions under which specific (*e.g.*, second and third tier) actions appear as appropriate. Second tier entries represent general recovery actions under which more specific actions may appear. Second tier actions that do not include specific third tier actions are usually programmatic activities that are not specific to this management unit, but that have been identified as applicable across the species' range; they appear in *italic type*. These actions may or may not have third tier actions associated with them. Third tier entries are actions specific to the Puget Sound Management Unit. These third tier entries appear in the implementation schedule that follows this section and are identified in the narrative outline by three levels of numerals separated by periods (*e.g*., 2.1.1)

The Puget Sound Management Unit volume of the recovery plan should be updated or revised as recovery actions are accomplished, or revised as environmental conditions change, and monitoring results or additional information become available. Revisions to the Puget Sound Management Unit recovery plan will likely focus on priority streams or stream segments within core areas where restoration activities have taken place and habitat or bull trout populations have shown a positive response. The Puget Sound Recovery Team should meet annually to prioritize recovery activities, review annual monitoring reports and summaries, and make recommendations to us.

Working with Federal, State, Tribal, and private entities, and in coordination with local governments, we need to secure quality habitat conditions for bull trout. These efforts should be coordinated with ongoing NOAA Fisheries and other salmon recovery actions to avoid duplication in planning and implementation.

In the Coastal-Puget Sound Distinct Population Segment, the Puget Sound and Olympic Peninsula Recovery Teams developed specific actions to remove the threats to bull trout in their respective management units. While there is general overlap for some actions between the two management units, other actions are specific to each management unit.

Appendix 2 provides a summary table linking the actions (third tier actions) needed for recovery with the reasons for decline (threat categories).

<u>Recovery Actions Narrative Outline</u>

1. Protect, restore, and maintain suitable habitat conditions for bull trout.

    1.1 Maintain or improve water quality in bull trout core areas or potential core habitat.

        1.1.1 <u>Identify and improve or remove unstable or problem roads causing sediment delivery</u>. Use existing information from State, Tribal, and U.S. Forest Service surveys and watershed analyses, Water Resource Inventory Area's habitat limiting factors analyses, Washington Department of Natural Resources' slope stability prediction model, local subbasin road inventories and assessments, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to identify problem roads (*e.g.*, roads with deep fills and undersized cross drains, inadequate cross drain spacing, and sidecast with potential to deliver or route sediment to streams). Stabilize roads, crossings, and other road-related sources of sediment delivery to streams, with a primary focus on bull trout spawning and rearing areas (local populations). Secondary focus would be on foraging, migration, and overwintering areas. Reduce forest road density. Known priority areas include North, Middle and South Forks Nooksack River, especially roads in drainages with history of debris flows (Nooksack core area); Illabot Creek, South Fork Sauk River (Lower Skagit core area); North and South Forks Skykomish River (Snohomish-Skykomish core area); Canyon Creek, Deer Creek, Upper South and North Fork Stillaguamish River, and Boulder River (Stillaguamish core area); Upper Cedar River (Chester Morse Lake core area); Upper Puyallup and Carbon River drainages (Puyallup core area). Secondary priority areas include the Pilchuck, Wallace, Tolt and Snoqualmie drainages (Snohomish-Skykomish core area).

1.1.2 <u>Improve routine road maintenance practices affecting water quality</u>. Some road maintenance practices have been identified as adversely affecting bull trout habitat where maintenance occurs on roads next to or near streams. Implement improved road maintenance protocols on all Federal, State, County, private, and city managed roads throughout Puget Sound core areas to avoid and minimize, sediment and contaminant input (*e.g.*, oil and grease, heavy metals, pesticides), riparian damage, and identify and correct fish passage barriers. Focus on inspecting roads and cross drains annually and during storm events, particularly those that have a history of sedimentation problems, those adjacent to streams, and all roads within drainages that have spawning and rearing habitat in core areas. High priority areas to initially focus efforts include Monte Cristo Road (Lower Skagit core area); South Fork Stillaguamish Sunrise Mine Road (Stillaguamish core area); Carbon River Road (Puyallup core area); and all forest roads in local populations.

1.1.3 Implement measures to restore natural thermal regime. Assess and eliminate or attempt to mitigate thermal effects on bull trout from temperature increases (non-point sources) that negatively impact receiving waters in spawning and rearing areas and in migratory corridors and foraging areas. Use Water Resource Inventory Area's habitat limiting factors analyses, Washington Department of Ecology's 303(d) lists, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to help prioritize areas. Primary focus is on the following local population areas: Lower South Fork Nooksack River and spawning and rearing tributaries to it, non-glacial spawning and rearing tributaries to North and Middle Fork Nooksack Rivers (Nooksack core area); North and South Forks of Stillaguamish River, Deer Creek (Stillaguamish core area); North and South Forks Skykomish River (Snohomish-Skykomish core area); and Greenwater and Clearwater Rivers (Puyallup core area). Efforts should also focus on foraging, migration and overwintering habitats, including the lower South Fork Nooksack River and tributaries, mainstem Nooksack River and tributaries, and Lower North Fork tributaries (Nooksack core area); Pilchuck, Wallace, Tolt and Snoqualmie drainages (Snohomish-Skykomish core area); Samammish and Lower Cedar Rivers (Lake Washington foraging, migration, and overwintering habitat); and Green River (Lower Green River foraging migration and overwintering habitat).

1.1.4 Reduce anthropogenic nutrient input. Reduce anthropogenic related nutrient delivery throughout the Puget Sound basin by improving sewage treatment and disposal, agriculture practices (*e.g.*, manure spreading, fertilizing), and silvicultural fertilizing practices. Develop ways to reduce negative impacts from the residential use of fertilizers.

1.1.5 Encourage the uptake of marine-derived nutrients from salmon carcasses into the freshwater ecosystem. This needs to be a basinwide effort with focus on the physical process to trap and cycle the nutrients into the freshwater environment, including riparian zones. This is facilitated by two processes: 1) the hauling of carcasses up into the riparian zone by animals (mammals and birds), and 2) the reestablishment of complex stream channels (braided channels or side channels, large woody debris incorporated into the channel structure, etc.) to trap and retain the carcasses. Explore the potential to modify salmon harvest management (see action 3.1.3) to assure a more consistent and large spawning escapement[†] of salmon to all core areas with anadromous bull trout populations, especially pink and chum salmon which seem to provide the largest benefit to char. Also conduct hatchery salmon carcass deployment efforts where appropriate.

1.1.6 Monitor water quality and meet water quality standards for temperature, nutrient loading, dissolved oxygen, and contaminants. Implement additional water temperature monitoring on State, Federal, Tribal, County, City, and private lands. Identify and correct causes of temperature exceedences (*e.g.*, riparian changes, hydrologic changes, debris flows) in bull trout spawning, rearing, foraging and migratory habitat. Evaluate current minimum forest practice regulations for sufficiency in maintaining adequate riparian shading for maintaining water quality standards. Increase monitoring and enforcement of water quality standards and implement the Total Maximum Daily Load program. Water quality is an acute problem in many of the lower basin tributaries of most core areas, and in some mainstem areas including South Fork and Middle Fork Nooksack Rivers, mainstem Nooksack River, Cornell, Gallop, Boulder, Racehorse, Canyon Lake, Howard, Clearwater, Anderson, Tenmile, Deer, Fishtrap, Bertrand, and Kamm Creeks, and Double and Duffner Ditches (Nooksack core area); North Fork Stillaguamish and Deer Creek (Stillaguamish core area); French and Allen Creeks (Snohomish-Skykomish core area); Greenwater, Clearwater, and White Rivers (Puyallup core area).

1.1.7 Identify, restore, and protect groundwater and hyporheic sources. Identify, restore, and protect groundwater and hyporheic sources and cold water refugia in local populations and in migratory and foraging habitats. Where forward looking infrared flights have occurred, protect identified refugia areas from ground or surface water withdrawals, and prioritize these areas for instream habitat improvements. Highest priorities for protection are those sources located in local and potential local populations and in critical migratory corridors and foraging areas, especially those that currently exceed water quality standards or have acute, chronic temperature problems. These include: South Fork, Middle Fork, and Lower Nooksack River (Nooksack core area); Stillaguamish River (Stillaguamish core area); Green River (Lower Green River foraging, migration, and overwintering habitat); White River, Clearwater and Greenwater River (Puyallup core area); and Nisqually River (Lower Nisqually foraging, migration, and overwintering habitat).

1.1.8 Reduce anthropogenic sediment and contaminant sources generated from agriculture practices. Identify and reduce fine sediment and contaminant sources (pesticides) from agriculture practices in watersheds of the Puget Sound Management Unit. Monitor effectiveness of sediment reduction projects. Highest priority areas include where agriculture exists above or adjacent to spawning and juvenile rearing habitats within core areas. Secondary priorities include mainstems and associated tributaries that provide foraging, migration, and postdispersal rearing. The Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas all have substantial agricultural use in lowland settings.

1.1.9 Reduce anthropogenic sediment sources generated from forest management. Identify and reduce coarse and fine sediment sources from forest management practices in watersheds of the Puget Sound Management Unit. Protect unstable slopes from timber harvest where there is potential for sediment delivery to downstream bull trout waters. Ensure that landslide frequencies and magnitudes approach natural background levels. Monitor effectiveness of sediment reduction projects. Where unstable slopes have the potential to deliver large woody debris to bull trout waters and adjacent riparian areas, leave trees to provide future sources of large wood and to attenuate sediment delivery. Priorities include timber management areas above or adjacent to core area spawning and rearing areas, particularly those that are inherently geologically unstable including areas in the Nooksack core area; Illabot Creek, Lower Cascade River, White Chuck River, Lower Bacon Creek in the Lower Skagit core area; Deer Creek, Canyon Creek, and South Fork Stillaguamish River in the Stillaguamish core area; Upper Mowich and Puyallup Rivers in the Puyallup core area.

1.1.10 Reduce anthropogenic sediment and contaminant sources generated from residential development and urbanization. Identify and reduce fine sediment and contaminant sources (including stormwater runoff, non-point source pollutants, and wastewater discharges) from residential and urban developments in watersheds of the Puget Sound Management Unit. Monitor effectiveness of sediment and contaminant reduction projects. Highest priority is where development and urbanization occur above or adjacent to spawning and rearing areas, and where it occurs adjacent to critical foraging, migration, and overwintering habitats. Most sources are currently adjacent to or upstream of mainstem rivers, estuaries, nearshore habitats and foraging tributaries. A reduction in sediment and contaminant sources within these waters is important due to potential sublethal effects on migratory and foraging bull trout, and potential lethal and sublethal impacts on bull trout prey species.

1.1.11 Maintain and improve instream flows. Ensure that minimum instream flows as established by Washington Department of Ecology or those required by other agreements or licenses, whichever is higher, are maintained. Locate and terminate unpermitted water withdrawals to restore adequate instream flows and prevent potential entrainment of juvenile bull trout. Increase compliance monitoring and enforcement of unauthorized withdrawals and enforcement action. Identify stream reaches where decreased instream flows limit bull trout spawning, rearing, foraging, migration, or overwintering and work to improve instream flows to more fully support these uses. Long-term efforts must included addressing overallocated basins or tributaries through water conservation, voluntary purchase or retirement of water rights, education, incentives, and enforcement.

1.2 Identify barriers or sites of entrainment for bull trout and implement actions to provide passage and eliminate entrainment.

1.2.1 Eliminate or minimize entrainment at diversions and ditches. Identify all diversions and artificial (completely manmade) ditches that have the potential to entrain bull trout. Screen all identified diversions and artificial ditches to meet State and Federal fish screen requirements where determined to have significant adverse impacts. Current identified priorities include the Bellingham Diversion, and potentially Excelsior powerhouse outfall/Nooksack Falls (Nooksack core area); Electron Diversion power canal (Puyallup core area); and Masonary Dam intakes (Chester Morse Lake core area).

1.2.2 Provide adequate fish passage around diversions and dams. Provide fish passage around diversions that have reduced population connectivity within watersheds. Diversions and dams currently reduce connectivity among local populations, and block access to potential spawning and juvenile/subadult rearing and foraging habitats. When upstream volitional passage is not feasible, establish protocols for determining when and where to relocate captured fish. Priority areas for restoring or improving local population connectivity include City of Bellingham Diversion (Nooksack core area); Gorge Dam and Baker River Dams (Lower Skagit core area); Ross Dam (Upper Skagit core area) and Buckley Diversion (Puyallup core area). Priority areas for restoring or improving connectivity to juvenile/subadult rearing and foraging habitats include: French Creek, Marshland pumping station, and the diversion dam on the Pilchuck River (Snohomish-Skykomish core area); and Howard Hansen Dam (Lower Green foraging, overwintering, and migration habitat).

1.2.3 Identify and eliminate culvert barriers. Inventory road crossings for blockages to upstream fish passage, and where beneficial to bull trout and other native fish, remove, replace or improve existing culverts that impede passage. Use existing inventories from State, Tribal, County, and

U.S. Forest Service surveys and watershed analyses, Water Resource Inventory Area's habitat limiting factors analyses, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling, and conduct additional inventories where needed to identify key problem culverts. Develop a prioritized program with schedules for barrier culvert removal, replacement, or modification to improve fish passage. Highest priorities for removal, replacement, or modification are in local populations (*e.g.*, Upper North Fork Nooksack [Hedrick, "Powerhouse," "Chainup," Lookout, Boyd, Kenny Creeks]; Upper Middle Fork [Loomis Creek], Lower South Fork [Johnson Creek]; and Upper Puyallup and Mowich River), while secondary priorities are tributaries to foraging, migration, and overwintering habitats.

1.2.4 <u>Identify and eliminate or modify tide gates, pump stations, and flood gates blocking access to bull trout habitat</u>. Inventory all tide gates, pump stations, and flood gates and evaluate the habitat blocked by each structure. Remove or modify those structures that block access to significant rearing and foraging habitats. Priority areas include lower river mainstems in core areas, and estuary and nearshore areas (Skagit, Lummi, Samish, Bellingham Bays) near rivers supporting core populations.

1.2.5 <u>Inform the public about the impacts of recreational barriers to migrating bull trout</u>. Inform the public about the impacts of recreational barriers (rock weirs) to bull trout spawners trying to access spawning grounds. Signs and educational material should be developed, stressing the deconstruction of these structures after their use, to ensure upstream passage of adult bull trout. High priority areas include spawning and rearing areas within proximity to recreational use sites. Known problem areas include South Fork Sauk

(Lower Skagit core area) and North Fork Skykomish River (Snohomish-Skykomish core area).

1.3 Identify impaired stream channel and riparian areas and implement actions to restore their appropriate functions.

1.3.1 Restore and protect riparian areas. Identify impaired riparian areas and restore vegetative cover to provide shade, canopy, riparian cover, and native vegetation. Use results from State, Tribal, and U.S. Forest Service surveys and watershed analyses, basin riparian assessment reports, Water Resource Inventory Area's habitat limiting factors analyses, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to help identify priority areas. Develop and implement a public awareness campaign regarding the effectiveness and necessity of maintaining and improving riparian areas for supporting salmonids. Focus on how to restore and protect riparian areas. Emphasize restoration of riparian areas by planting native species appropriate to provide shade and functional large woody debris to form and maintain stream habitat. Highest priorities for restoration include impaired riparian areas along streams in identified local populations. Secondary priorities for restoration include riparian areas along tributaries to mainstem migratory, foraging, and overwintering habitats, and riparian areas along lake shorelines. Priority areas for protection include: developing rural areas within identified local populations; and foraging and migration, and overwintering areas with existing high quality habitat or habitat on a trajectory towards recovery.

1.3.2 Identify, evaluate, and restore overwintering habitat in the mainstem rivers and tributaries. In all core areas identify specific overwintering areas used by bull trout in the mainstem rivers and estuaries and classify general overwintering habitat for use, current condition, and restoration potential. Determine where overwintering habitat areas are degraded by factors such as sediment accumulation, bedload movement, or low flows in all core areas. Implement necessary restoration activities as described throughout this section to improve overwintering habitat.

1.3.3 Identify and restore foraging waters with high restoration benefit. Use Water Resource Inventory Area's habitat limiting factors analyses, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling, or conduct additional inventories where needed to select specific areas where restoration of known or potential foraging areas will contribute the most to bull trout recovery. Highest priorities are mainstems downstream of local populations used by anadromous life histories to reach marine habitats. These serve not only for adult migration, but also for subadult and adult foraging, overwintering and holding, and smolt migration. Secondary priorities are larger tributaries to mainstem reaches that now have or have potential for high salmon use.

1.3.4 Reduce stream channel degradation and increase channel complexity. Where feasible remove existing and prevent future bank armoring (bulkheads and riprap) and channel constrictions (*e.g.*, dikes and levees) associated with development and agriculture. Restore connectivity to floodplain. Recreate lost off-channel habitat, and opportunities for off-channel habitat formation through time by protecting channel migration areas from encroachment during new construction or reconstruction of these structures. Priority areas include most lower mainstem rivers in all core areas. Results from completed Water Resource Inventory Area Ecosystem Diagnostic Treatment modeling for Chinook salmon should help establish priorities.

1.3.5 Practice non-intrusive flood control and flood repair activities. Provide technical assistance to Counties, Cities, and private landowners to develop options for fish friendly flood control methods and repair techniques. Ensure that negative effects to bull trout habitat from ongoing flood control activities (*e.g.*, dredging, woody debris removal, channel clearing, hardened bank stabilization, and riparian removal from dikes and levees) are avoided or minimized. Alternatives should emphasize restoration of floodplain connectivity and the elimination or setback of existing armored banks, dikes and levees to restore habitat forming processes. Focus is on the Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas.

1.3.6 Reduce development impacts on streams, floodplains, and lake shores. Avoid and minimize further development that will constrict or constrain stream channels, degrade riparian areas, negatively impact ground water and surface water interactions, or in any other way degrade stream channel functions. Reduce impacts within floodplains and lake shores through development and implementation of appropriate zoning restrictions, restoration, and targeted acquisition (by Counties, land trusts, etc.) of prioritized lands.

1.3.7 Reduce transportation corridor impacts on streams. Reduce impacts from the legacy of road and railroad encroachment (*e.g.*, sedimentation, channel straightening, channel relocation, channel constriction, and undersized bridges).

Avoid future bank armoring (bulkheads and riprap) and channel constrictions (*e.g.*, dikes, levees, undersized bridges) associated with transportation corridor construction and maintenance and, where necessary and feasible, remove existing bank armoring and channel constrictions to allow natural channel migration and formation of off-channel habitats. Avoid placing roads and bridges on alluvial fans, where channel migration naturally occurs over time. Results from completed Water Resource Inventory Area Ecosystem Diagnostic Treatment modeling for Chinook salmon and available Washington State Department of Transportation Corridor Analyses should help in establishing priorities. Priority areas for action are transportation corridors along most mainstem rivers in core areas, and some areas within local populations. Examples of roads within local populations include: State Route 542 which has impacted Canyon Creek, Glacier Creek, Boulder Creek, and the North Fork Nooksack (Nooksack core area); State Route 20 which has impacted Ruby Creek and Granite Creek (Upper Skagit core area); and State Route 530 which has impacted the North Fork Stillaguamish River (Stillaguamish core area).

1.3.8 <u>Improve grazing practices</u>. Develop, implement, and adaptively manage livestock grazing plans which include actions (*e.g.*, riparian fencing, revegetation, off-channel watering) and performance standards and targets for floodplains, riparian vegetation, and streambanks that protect bull trout habitat and water quality. Focus efforts on the Nooksack, Lower Skagit, Stillaguamish, and Snohomish-Skykomish core areas.

1.3.9 <u>Restore natural stream channel morphology</u>[†]. Conduct stream channel restoration activities if they are likely to be beneficial to bull trout and other native fish, and only where similar results cannot be achieved by other less costly and intrusive means. Current identified priorities in spawning and rearing areas include: Boulder Creek (Chester Morse Lake core area); Canyon, Boulder, Hutchinson Creeks (Nooksack core area); Deer Creek (Stillaguamish core area); and Upper North Fork Skykomish (Snohomish-Skykomish core area). Priorities in foraging, migration, and overwintering areas include “straightened” mainstem river reaches and tributary streams entering mainstem rivers (*e.g.*, South Fork Nooksack River and Fishtrap Creek [Nooksack core area]).

1.3.10 Enhance and restore instream habitat. Increase or enhance instream habitat by restoring habitat diversity. Projects should focus on the enhancement of habitat elements such as large woody debris, log jams, and complex channels in the short-term, and the restoration of processes that support these habitat elements in the long-term. High priorities are mainstem areas identified by the Water Resource Inventory Area’s habitat limiting factors analyses, Water Resource Inventory Area’s Ecosystem Diagnostic Treatment modeling, and other instream habitat assessments.

1.3.11 Protect riparian and stream channel habitat at managed and unmanaged campgrounds, trail systems, and recreational sites. Develop riparian and stream channel management plans to protect migration, spawning, and rearing habitat adjacent to trail systems (hiking, off- road vehicle, horse), camping, and recreation sites. Relocate campgrounds and trail systems out of riparian areas when necessary to avoid impacts to bull trout habitat. Inventory, close, and restore areas impacted by unauthorized off-road vehicle trails in or adjacent to riparian areas, and close unauthorized stream fords in all core areas. Restore and protect riparian and stream channel habitat along heavily used trails and trail heads, and locate new trails outside of riparian areas.

Currently identified priority campgrounds and trails include: Excelsior Campground (Nooksack core area); Monte Cristo recreational area, Downey Creek Trail (Lower Skagit core area); Sunrise Mine recreational area (Stillaguamish core area); and Troublesome Creek (Snohomish-Skykomish). Currently identified areas for reducing off-road vehicle impacts include Bear Creek Slough complex, Hutchinson, and Racehorse Creeks (Nooksack core area); North Fork Skykomish River (Snohomish-Skykomish core area); and South Fork Sauk River (Lower Skagit core area).

1.4 Operate dams to minimize negative effects on bull trout in reservoirs and downstream.

1.4.1 Reduce reservoir operation impacts. Review dam operation plans (*e.g.*, South Fork Tolt, Baker River, and Spada Dams) for potential impacts on bull trout and their forage base. Continue to evaluate reservoir operational concerns in Chester Morse Lake, and provide operating recommendations if necessary (Chester Morse Lake core area). Evaluate temperature and attraction flow concerns at the Deringer tailrace outlet below Lake Tapps (Puyallup core area).

1.4.2 Provide sufficient instream flow downstream from dams and diversions. Ensure existing instream flows (timing and quantity) are sufficient to support all affected bull trout life stages. Address ramping rates, access, and utilization by bull trout, and changes to benthic invertebrate communities. Priorities for evaluation and modification are Bellingham Diversion (Nooksack core area); Baker River Dams and Gorge Dam (Lower Skagit core area); Diablo and Ross Dams (Upper Skagit core area); and Buckley Diversion and Electron Diversion (Puyallup core area). Ensure instream flows for proposed hydropower projects in bull trout streams are based on migratory bull trout life history rather than life histories of resident cutthroat or rainbow trout. If obsolete facilities are restarted, ensure that improvements are made as needed to prevent entrainment, provide adequate instream flows to support all affected life stages, provide appropriate ramping, and provide tailrace protection (*e.g.*, Excelsior/Nooksack Falls facility).

1.5 Identify upland conditions negatively affecting bull trout habitats and implement actions to restore appropriate functions.

1.5.1 <u>Update and/or review local Forest Service or other watershed analyses</u>. Review management activities and short- and long-term goals for compatibility with bull trout recovery in North Fork Nooksack River, Canyon Creek, Sauk River and Sauk River Forks, South Fork Stillaguamish, Deer Creek, and Carbon River. Review prescriptions in State watershed analyses to ensure they are consistent with bull trout recovery, and reconvene prescription teams as needed to revise them.

1.5.2 <u>Upgrade or decommission existing and potential problem roads</u>. Continue the upgrading or decommissioning of problem roads that adversely affect or have potential to adversely affect bull trout streams. Inventory and decommission orphan road systems. Use road maintenance and abandonment plans required under State forest practices, Water Resource Inventory Area’s habitat limiting factors analyses, and results from Water Resource Inventory Area’s Ecosystem Diagnostic Treatment modeling to help determine priority roads or segments for decommissioning within each core area. High priorities are orphaned and other roads with demonstrated problems that continue to pose a threat to downstream spawning and rearing areas within local populations. Strive to reduce overall road densities within local populations.

1.5.3 Minimize levels of effective impervious surface from development. Minimize the effects of impervious surfaces by protecting hydrologically mature forest cover† to the maximum extent feasible, and by implementing other low impact development measures. Alternatively, if lacking such forest condition, protect the opportunity to reestablish forest cover by minimizing amount of clearing, buildings, and infrastructure. If reestablishment of forest cover is not possible due to existing high intensity development (*e.g.*, already built-out areas of cities and unincorporated urban growth areas), then require highest levels of stormwater engineering and integrate low impact development measures (*e.g.*, impervious surface removal, roof top gardens) where possible. For rural areas (*i.e.*, lands not in cities or not within unincorporated areas with existing high density development) draining to bull trout foraging, migration and overwintering areas, maintain at least (but preferably more than) 65 percent hydrologically mature forest cover and no more (and preferably much less) than 10 percent effective impervious area. For cities and unincorporated areas with existing high density development, require the highest level of stormwater engineering available. For catchments draining to areas that are used for spawning and early rearing areas, developments should strive for zero percent effective impervious surfaces (*i.e.*, all stormwater should be treated on site to match predevelopment peaks, duration and quality) and at least (but preferably much more than) 65 percent forest cover. Generally, protected forest cover should be contiguous with riparian areas, steep slopes, aquifer recharge areas and wetlands. Accomplish these protections through appropriate zoning and development standards.

1.6 Identify impaired estuarine and nearshore marine habitats and implement actions to restore their appropriate functions.

1.6.1 <u>Identify and remediate contaminant sites in estuarine and nearshore marine areas</u>. Identify estuarine and nearshore marine sites with contaminated sediments and structures (*e.g.*, treated wood piles) that pose a significant exposure risk to bull trout or their forage species, and address contaminant exposure by site capping or other remediation. High priority sites include those in close proximity to known and potential marine forage fish spawning areas and bull trout subadult and adult foraging habitats. High priority locations include Commencement Bay, Lower Duwamish and Elliott Bay, and Bellingham Bay.

1.6.2 <u>Reduce impacts of development and transportation corridors along estuarine and marine shorelines</u>. Reduce impacts along estuarine and marine shorelines by developing appropriate zoning restrictions and through acquisition of lands by Counties, land trusts, etc. Where feasible remove or reduce existing bank armoring (bulkheads and riprap), dikes, in-water and over-water structures (*e.g.*, pilings, docks) to restore or enhance altered shorelines and adjacent riparian areas. Avoid further development that will interfere with natural bluff and beach erosion processes, degrade vegetated intertidal habitats and forage fish spawning areas, or degrade nearshore riparian areas. Ensure measures are in place at all shoreline facilities that will avoid potential release of contaminants into marine waters. Highest priority areas for restoration include those in or in close proximity to known and potential marine forage fish spawning areas and bull trout subadult and adult foraging habitats, especially those directly linked to known core areas. Other high priority areas include nearshore habitats linking core habitats and foraging, migration, and overwintering habitats.

1.6.3 Restore or recreate intertidal foraging habitats in key areas. Restore or recreate intertidal habitat that has been previously altered or destroyed in estuaries and nearshore areas associated with core areas. Priority areas include Bellingham Bay, Lummi Bay, Samish Bay, Skagit Bay, Shilshole Bay, Elliott Bay, and Commencement Bay. Secondary priorities include estuarine areas or mouths of small anadromous salmon streams outside of core areas discharging into Puget Sound.

2. Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout.

2.1 Develop, implement, and enforce public and private fish stocking policies to reduce stocking of nonnative fish that potentially affect bull trout.

2.1.1 Review and analyze effectiveness of current fish stocking policies. Ensure planting of nonnative fish does not occur in areas that drain into bull trout habitat within core areas. Recommend actions that will prevent or reduce negative impacts to bull trout from nonnative fish stocking, and monitor for increased fishing pressure, alterations to prey base, predation, and competition.

2.2 Evaluate policies for preventing illegal transport and introduction of nonnative fishes.

2.2.1 Review existing enforcement of current policies for preventing illegal transport and introduction of nonnative fishes. Review existing policies for their effectiveness and make changes necessary for improved enforcement.

2.3 Provide information to the public about ecosystem concerns of illegal introductions of nonnative fishes.

2.3.1 Discourage unauthorized fish introductions. Focus an intensive public outreach campaign on the Puget Sound basin to reduce the potential spread of illegally introduced nonnative fish species, especially brook trout and lake trout. Outreach should emphasize ecological consequences of spreading nonnative fish species.

2.4 Evaluate biological, economic, and social effects of control of nonnative fishes.

2.4.1 Review existing protocols for eradicating, suppressing, or managing nonnative fish populations and implement protocols where needed. Conduct research and analysis of existing protocols to determine the most effective methods for suppressing or eradicating nonnative fishes (especially brook trout) where they overlap with bull trout distributions and are negatively impacting bull trout. Evaluate the impact of existing and proposed liberal brook trout limits in the Puget Sound Management Unit on reducing populations and limiting expansion of brook trout.

2.5 Implement control of nonnative fishes where found to be feasible and appropriate.

2.5.1 Determine distribution and abundance of nonnative fish (brook trout and westslope cutthroat trout) and identify overlap with bull trout. Identify distributional overlap using existing stream and fish survey data, conduct surveys in unsurveyed areas, and monitor changes in distribution. Map known brook trout distributions for all core areas. Prioritize local population areas where spawning and rearing has been documented, followed by potential local population areas. Current priorities for brook trout include the Nooksack, Upper Skagit, Snohomish-Skykomish (Foss River), and Puyallup core areas. Current priorities for westslope cutthroat trout include the Lower Skagit (Upper

Baker River and tributaries to Baker Lake) and Stillaguamish core areas (South Fork Stillaguamish and Deer Creek).

2.5.2 Evaluate brook trout impacts to migratory bull trout populations. Evaluate to what extent resident brook trout adversely impact migratory populations of bull trout in the Puget Sound Management Unit. Focus for these efforts should be on the Nooksack, Upper Skagit, and Puyallup core areas.

2.5.3 Experimentally remove established brook trout populations from priority streams. Evaluate opportunities for experimental removal of brook trout in areas where there is a potential problem of competition with bull trout, and in areas where there is a reasonable likelihood for future dispersal into bull trout streams. Where brook trout appear to be expanding in distribution in areas that offer suitable habitat for bull trout, eradication may be required. Efforts should be focused on streams such as Hutchinson Creek, fire pond draining to Upper Howard and Skookum Creeks (Nooksack core area); Hozomeen Creek (Upper Skagit core area); and Upper Carbon River tributaries (Puyallup core area).

2.6 Develop actions to reduce negative effects of nonnative taxa on bull trout.

2.6.1 Remove invasive nonnative plants that are limiting the effectiveness of riparian areas and restore with native vegetation. Remove nonnative plants (*e.g.*, reed canary grass, Japanese knotweed) that are limiting the effectiveness of riparian areas and altering channel conditions along bull trout streams. Develop and implement measures to prevent their spread into other areas. Identified priorities include Nooksack, Lower Skagit, and Stillaguamish core areas.

2.6.2 <u>Continue control of *Spartina* in estuarine and nearshore areas</u>. Continue ongoing *Spartina* (cord grass) control in estuarine and nearshore areas. Ensure methods are compatible with bull trout recovery. High priorities include Padilla Bay, Skagit Bay, Port Susan Bay, and Camano Island and Whidbey Island nearshore areas.

3. Establish fisheries management goals and objectives for compatibility with bull trout recovery, and implement practices to achieve goals.

3.1 Develop and implement State and Tribal native fish management plans integrating adaptive research.

3.1.1 <u>Integrate research and monitoring results into native fish management plans and related information resources</u>. Update native fish management plans [*e.g.*, bull trout/Dolly Varden Management Plan (WDFW 2000b), Salmonid Stock Inventory (SaSI) appendix for bull trout and Dolly Varden (WDFW 1998), Wild Salmonid Policy (WDFW 1997), Washington Department of Fish and Wildlife's spawn survey database] with the latest results from bull trout research and monitoring including distribution and population status. Develop and implement native fish management plans that emphasize timely integration of research results into management programs.

3.1.2 <u>Protect remaining bull trout strongholds and native species complexes</u>. Protect integrity of areas with intact native species assemblages *(e.g.*, upper Skagit River, upper North Fork Skykomish River, upper Cedar River). Identify and maintain these complexes with appropriate management and methods. Management actions that protect intact anadromous salmon complexes will benefit bull trout by maintaining the prey base and preserving habitat for cold water salmonids. Large abundances of pink and chum salmon are of particular benefit to bull trout. These salmon species not only supply nutrients to the freshwater environment, but they also supply loose eggs (dislodged during mass spawning) in the fall and large abundances of fry in the spring that are direct food sources for bull trout.

3.1.3 Provide increased forage opportunities in freshwater. Establish improved forage opportunities by managing for increased salmon escapement complimentary to related habitat improvements to increase salmon productivity and abundance. Priority watersheds include the Nooksack, Stillaguamish, and Puyallup core areas.

3.1.4 Increase biomass of marine forage base. Improve marine prey base (*e.g.*, surf smelt, sandlance, herring) known to be important to bull trout through appropriate forage fish habitat protection and management measures.

3.2 Evaluate and prevent overharvest and incidental angling mortality of bull trout.

3.2.1 Evaluate the impacts of harvest on bull trout populations. Track changes in population characteristics (abundance, life histories, age structure, etc.) to assess the impacts of angling mortality from recreational bull trout fisheries in the Lower Skagit and Snohomish-Skykomish core areas. Ensure recovery objectives for individual core areas are not compromised by current harvest strategies. Maintain repeat spawning levels (measured as the percent of adult migratory spawners over 508 millimeters [20 inches]) at 50 percent or more annually. Assess impacts of the Tribal bull trout fishery in the Puyallup core area. Work with Tribes to ensure harvest is at levels that will support recovery objectives for the core area.

3.2.2 Evaluate and minimize incidental mortality of bull trout in other fisheries. Determine level of incidental catch and related mortality in other fisheries. Review and modify State, National Park, and Tribal fisheries management plans, guidelines, and policies to insure that incidental mortality of bull trout is minimized. Fisheries intercepting adult bull trout are the highest priority for review. Work with Washington Department of Fish and Wildlife, Tribes, National Park Service, and NOAA Fisheries to develop and implement regulations that modify the timing and methods (*e.g.*, selective gear, no-bait, mesh size) in these fisheries to reduce incidental catches and mortalities of bull trout.

3.2.3 Increase enforcement efforts with special emphasis on bull trout spawning and staging areas to eliminate illegal harvest. Increase enforcement and posting of “closed waters” and bull trout informational signs in all readily accessible staging and spawning areas, and in areas with known history of illegal harvest. Priority areas include all known staging and spawning areas for bull trout, especially Sylvester Falls (South Fork Nooksack River); downstream of Nooksack Falls (North Fork Nooksack River); Downey Creek and Buck Creek (Suiattle River); Sauk River above Elliott Creek (Skagit River); tributary mouths to Ross Lake; the North Fork Skykomish River between Bear Creek Falls and Deer Falls; and Masonry Pool (Chester Morse Lake).

3.2.4 Expand angler and public awareness efforts. Develop an outreach program to provide information to the general public and key contacts such as anglers, outfitters, and guides about bull trout identification, fishing regulations, management issues, and the importance of bull trout and their habitats. Evaluate combining bull trout outreach with other fish conservation efforts. Develop information signs for key habitat areas, increase informational exposure in areas such as agency web sites (*e.g.*, Montana Fish Wildlife and Parks bull trout identification and education website, <http://www.fwp.state.mt.us/bulltroutid/default.htm>), and develop a program for presenting fish conservation information to key area schools.

3.2.5 <u>Coordinate with British Columbia on harvest management strategies</u>. Coordinate and work closely with British Columbia Ministry of Water, Land, and Air Protection to carefully monitor the potential effects of regulated bull trout harvest in British Columbia waters (Chilliwack Lake, Ross Lake, Upper Skagit River) on recovery in the United States.

3.3 Evaluate potential effects of introduced fishes and associated sport fisheries on bull trout recovery and implement actions to minimize negative effects on bull trout.

3.3.1 <u>Monitor and evaluate effects of planted hatchery fish on bull trout, especially effects related to increased competition, disease, and predation</u>. Continue to monitor and evaluate effects of stocking hatchery salmon smolts and trout on bull trout populations. Review fish stocking programs to assure those programs are not contributing to significant levels of increased competition, disease, or predation that could interfere with bull trout recovery. Ensure that lake and pond releases of planted trout will not compete with or prey upon bull trout in or downstream of these areas.

3.4 Evaluate effects of existing and proposed fishing regulations on bull trout.

3.4.1 <u>Continue to monitor and evaluate the effects of the current minimum size limit on existing recreational bull trout fisheries</u>. Monitor for changes in age structure and size of spawners in current bull trout fisheries. Evaluate application of alternative harvest size limit (*e.g.*, slot limit, larger minimum harvest size) to bull trout fisheries.

3.4.2 Identify important bull trout spawning and staging areas that may require special regulations. Where populations are depressed or fishing pressures are heavy in bull trout spawning and staging locations, special regulations may need to be adopted to minimize fishing impacts.

4. Characterize, conserve, and monitor genetic diversity and gene flow among local populations of bull trout.

4.1 Incorporate conservation of genetic and phenotypic[†] attributes of bull trout into recovery and management plans.

4.1.1 Develop and implement a genetics study plan for future collection and analysis of genetic samples from local populations. Use genetic molecular analysis to delineate and describe the genetic population structure within the Puget Sound Management Unit. Complete analyses of backlogged tissue samples (*e.g.*, Snohomish-Skykomish core area) and recently collected tissue samples (*e.g.*, Chester Morse Lake core area) so results can be incorporated into a comprehensive genetics study plan for the Coastal Puget Sound Distinct Population Segment.

4.1.2 Determine level of interaction between bull trout and Dolly Varden populations. Evaluate the level of interaction between sympatric (co-occurring) bull trout and Dolly Varden populations within core areas and incorporate results in the management of both species. Focus efforts on Upper Skagit and Nooksack core areas with known populations of Dolly Varden, and in the Chilliwack core area with suspected populations.

4.2 Maintain existing opportunities for gene flow among bull trout populations.

4.2.1 Evaluate level of gene flow among core areas. Determine the level (frequency and amount) of gene flow among and within core areas that are linked by marine waters. Design and implement research efforts to determine full extent of anadromous bull trout migration patterns and use between core areas; foraging, migration, and overwintering habitats; and marine areas.

4.3 *Develop genetic management plans and guidelines for appropriate use of transplantation and artificial propagation*[†] .

It will be necessary to establish genetic reserve protocols and standards for initiating, conducting, and evaluating captive propagation programs. It may also be necessary to artificially propagate bull trout to preserve fish that are likely to be extirpated or to conduct research. Protocols will be needed to standardize the process and prevent detrimental effects on the donor population and captive fish, for determining when transplantation and artificial propagation is necessary, how to conduct these activities, and how to evaluate their effectiveness.

*Transplantation and artificial propagation of bull trout is not proposed for the Puget Sound Management Unit at this time.

5. Conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery actions.

5.1 Design and implement a standardized monitoring program to assess the effectiveness of recovery efforts affecting bull trout and their habitats.

5.1.1 Design and implement a population monitoring strategy for the Puget Sound Management Unit. Design and implement a monitoring strategy taking into account the unique conditions (*e.g.*, glacial turbidity, larger spawning and rearing tributaries, anadromous life history forms, remoteness of spawning sites) in the Puget Sound Management Unit, and revise the strategy as necessary under the principles of adaptive management. Develop a range of alternative methods for assessing population abundance. Add a monitoring component for foraging, migration, and overwintering habitats (*e.g.*, lower Green River, lower Nisqually River) that are identified as essential for recovery.

5.1.2 Evaluate existing recovery measures over time. Conduct an ongoing evaluation of existing recovery measures established for each core area to determine whether these require revision as new information is collected through research. A standardized monitoring and assessment program needs to be developed and implemented to evaluate recovery criteria, assess and improve management actions, and ensure a coordinated strategy for the future. The program should include a protocol to reliably estimate bull trout abundance and population structure over time. Coordinate these efforts with the Washington State Comprehensive Monitoring Strategy being develop for measuring success in recovering salmon and maintaining watershed health.

5.2 Conduct research evaluating relationships among bull trout distribution and abundance, bull trout habitat, and recovery actions.

5.2.1 Determine complete distribution of anadromous, fluvial, adfluvial, and resident bull trout and habitats used by each life stage. Continue implementation of existing bull trout population abundance and distribution studies and initiate new studies. Highest priority is to identify and map all spawning and rearing areas within core areas. Efforts should initially focus on the Nooksack, Stillaguamish, and Puyallup core areas. For anadromous, fluvial bull trout, continue to determine full extent of foraging, migration, and overwintering habitat.

5.2.2 Determine migratory pathways, patterns, and habitat preferences of anadromous bull trout in the Puget Sound Management Unit. Design and implement research efforts to determine full extent of anadromous bull trout migration patterns and use between core areas, foraging, migration and overwintering habitat areas (*e.g.*, Samish, lower Green), and within marine areas. Evaluate depth and other habitat preferences in estuarine and marine areas.

5.2.3 Conduct migrational studies for the Puget Sound Management Unit and coordinate with the Olympic Peninsula Management Unit and British Columbia. Information collected from these efforts will provide a more complete understanding of adult bull trout habitat requirements and the interrelationship of anadromous populations between the two management units and British Columbia. Efforts in the Chilliwack and Upper Skagit core areas will provide us critical information about the watershed-scale habitat requirements of bull trout populations in these transboundary systems.

5.2.4 Identify and assess complete estuarine and marine forage base for bull trout. Conduct research to identify complete forage base utilized by bull trout in estuarine and marine habitats. Assess current condition of this forage base and evaluate its long-term role in recovery. This includes identifying forage species of greatest importance for various life stages, adequate distribution of these forage species for bull trout, and necessary abundance levels of forage fish species to support recovery.

5.2.5 Determine extent of effects from contaminant exposure. Evaluate the significance of contaminant (*e.g.*, herbicides, pesticides, heavy metals, polyaromatic hydrocarbons, estrogenic compounds) exposure to bull trout in freshwater, estuarine, and marine habitats. Assess contaminant levels within individuals across age classes, evaluate lethal and sublethal effects and pathways of exposure, and assess potential overall effect to individual core areas. Also evaluate significance of contaminant exposure on their prey base, such as Cherry Point herring population. Current high priority areas include Bellingham Bay, Snohomish River estuary, Commencement Bay, and Duwamish River/Elliott Bay.

5.2.6 Evaluate importance of streams with only incidental bull trout presence. Evaluate the importance and contribution of core area tributaries or independent streams (*e.g.*, Whatcom Creek) directly flowing into Puget Sound currently assumed to have only limited incidental bull trout use (*i.e.*, for foraging or refuge). Determine which of these tributaries and independent streams are most likely necessary for supporting population expansion and/or long-term persistence in core areas.

5.2.7 Identify key habitat features within freshwater and marine habitats. Additional research is necessary to identify key habitat features in both freshwater and marine habitats to ensure habitat protection, restoration, and enhancement activities address critical limiting factors. Priorities include identification of key groundwater sources, hyporheic areas, and other cold water refugia; identification of desired water temperature regimes in river and tributary reaches used for foraging and migration; and identification of key habitat features required to support bull trout in migratory corridors and overwintering areas.

5.2.8 Monitor additional local populations to provide more accurate abundance estimates for each core area. Establish an appropriate number of representative spawning index areas for each core area. Highest priority is in core areas inconsistently or not currently monitored (*i.e.*, Chilliwack, Nooksack, Upper Skagit, Stillaguamish, and Puyallup core areas).

5.2.9 Determine actions necessary to restore spawning and rearing in potential local populations. Identify and evaluate actions that will be required to reestablish a sufficient level of spawning and rearing within currently identified potential local populations.

5.3 Conduct evaluations of the adequacy and effectiveness of current and past best management practices in maintaining or achieving conditions conducive to bull trout recovery.

5.3.1 Develop a sediment monitoring program. Develop a sediment monitoring program and focus collection of periodic sediment samples in bull trout spawning tributaries to determine impact of management actions on delivery of fine sediments. Monitor all core areas where management activities may potentially release sediment into spawning, rearing, and migratory areas.

5.3.2 Develop a temperature monitoring program. Develop a temperature monitoring program and focus collection of periodic temperature samples in bull trout spawning tributaries to determine impact of management actions on stream temperatures. Monitor all core areas where management activities may potentially increase temperature in spawning, rearing, and migratory areas.

5.3.3 Evaluate and improve existing forestry best management practices. Evaluate and improve existing forestry best management practices to ensure they provide for conditions (biological functions) necessary for bull trout recovery. Implement and expand monitoring of compliance and effectiveness of current Washington Forest Practices as described by the Forest and Fish Report (FFR 1999), including effectiveness of riparian protection measures on non-fishbearing streams in maintaining adequate temperatures in downstream bull trout waters. Implement adaptive management to ensure forest practices provide adequate protection to bull trout on private lands.

5.3.4 Evaluate and improve existing agricultural conservation practices. Evaluate and improve existing agricultural conservation practices to ensure they provide for conditions (biological functions) necessary for bull trout recovery. Continue and expand monitoring of compliance and effectiveness of mandatory conservation practices (Clean Water Act, Water Pollution Control Act and Dairy Nutrient Management Act) and effectiveness of voluntary conservation practices. Recommend adjustments to and revise conservation practices to correct any documented deficiencies where those practices are ineffective in supporting adequate habitat conditions for bull trout on private lands. Provide farmers with information about the functions and importance of functional riparian areas, and develop incentives for improving riparian conditions in agricultural settings.

5.3.5 Evaluate and improve existing and proposed development best management practices. Evaluate and improve existing and proposed development best management practices (including stormwater management and treatment practices) to ensure they provide for conditions (biological functions) necessary for bull trout recovery. Monitor compliance and effectiveness of State and local best management practices for development. Recommend adjustments to and revise best management practices to correct any documented deficiencies where those practices are ineffective in supporting adequate habitat conditions for bull trout.

5.4 Evaluate effects of disease and parasites on bull trout, and develop and implement strategies to minimize negative effects.

*Evaluating the effects of disease and parasites on bull trout is not an action proposed for the Puget Sound Management Unit at this time; although these factors may pose threats to bull trout in other parts of their range, to our knowledge they do not currently pose any significant threat to bull trout in this area.

5.5 Implement research and monitoring studies to improve information concerning the distribution and status of bull trout.

5.5.1 Develop a predictive model of suitable habitat used by juvenile and resident bull trout. Development of a suitable habitat model for bull trout in the Puget Sound Management Unit would help to refine prioritization of areas for surveys intended to detect new spawning or juvenile rearing sites. A suitable habitat model would also help to prioritize areas for recovery efforts.

5.5.2 Investigate potential use of the upper Green River by bull trout, and investigate habitat suitability. Conduct additional surveys to determine presence of remnant bull trout population in the upper Green River basin. Evaluate habitat suitability in the upper Green River for expanding current foraging, migration, and overwintering habitat, and evaluate habitat suitability for spawning and rearing in the upper Green River basin for possible establishment of an additional core area.

5.5.3 Investigate potential use of the upper Nisqually River by bull trout. Conduct additional surveys to determine presence of remnant bull trout population(s) in the upper Nisqually River basin.

5.6 Identify evaluations needed to improve understanding of relationships among genetic characteristics, phenotypic traits, and local populations of bull trout.

5.6.1 Determine the life history requirements and interactions of overlapping resident and migratory bull trout populations. The Puget Sound Management Unit has a number of local populations containing both resident and migratory (anadromous, adfluvial, and fluvial) forms. An understanding of specific habitat requirements and interrelationship between resident and migratory forms will assist with monitoring and evaluating the recovery status of bull trout.

6. Use all available conservation programs and regulations to protect and conserve bull trout and bull trout habitat.

6.1 Use partnerships and collaborative processes to protect, maintain, and restore functioning core areas for bull trout.

6.1.1 Coordinate bull trout recovery with other listed salmonid species recovery efforts. The Puget Sound Recovery Team will coordinate the implementation of bull trout recovery actions with Puget Sound Chinook salmon recovery measures and other general salmon recovery efforts to avoid duplication of effort and maximize the use of available resources.

6.1.2 Ensure protection of the highest quality spawning and rearing habitats remaining within each core area through measures including conservation land purchases and easements. Use partnerships to develop habitat conservation plans, conservation land purchases, and easements within local populations. Maintain and promote State, Federal, and non-governmental land management programs that protect the best remaining spawning and rearing habitat within the management unit. Examples include Federal wilderness, Wild and Scenic Rivers, State and Federal parks, and land trusts.

6.2 Use existing Federal authorities to conserve and restore bull trout.

6.2.1 Ensure adequate protection for bull trout at all life stages under Washington State Water Quality Standards. Ensure that new and existing water quality criteria are protective of all bull trout life stages and their prey base. Support development of research directed at evaluating exposure to contaminants and their effects on bull trout. Determine optimal temperature requirements for subadult and adult life stages and develop appropriate water quality standards to protect these life stages in the areas where they occur (*i.e.*, mainstem corridors, core area tributaries with anadromous use downstream of local populations, and independent tributaries used or potentially used by subadult and adult bull trout for foraging, migration, and holding).

6.3 Enforce existing Federal, State, and Tribal habitat protection standards and regulations and evaluate their effectiveness for bull trout conservation.

6.3.1 Ensure restrictions on recreational mineral prospecting and placer mining in bull trout habitat are effective. Evaluate compliance with and effectiveness of restrictions in protecting bull trout habitat as described by the State's rules and regulations for mineral prospecting and placer mining ("Gold and Fish" pamphlet; WDFW 1999). Modify to improve effectiveness if necessary. Priority areas for evaluation include South Fork of the Sauk River (Lower Skagit core area), and Ruby Creek drainage (Upper Skagit core area).

7. Assess the implementation of bull trout recovery by management units and revise management unit plans based on evaluations.

7.1 Convene annual meetings of each management unit recovery team to review progress on recovery plan implementation.

7.1.1 <u>Generate progress reports on implementation of the bull trout recovery plan</u>. Annual reviews are necessary to track progress in implementing the recovery plan. Annual reports can be used to identify successful approaches for implementing recovery actions and direct where efforts should be placed within management units.

7.2 Develop and implement a standardized monitoring program to evaluate the effectiveness of recovery efforts.

7.2.1 <u>Develop and implement a standardized monitoring program to evaluate the effectiveness of recovery efforts</u> (coordinate with recovery action 5.1). A standardized monitoring program is needed to evaluate achievement of recovery objectives and provide information to adaptively manage and improve recovery efforts.

7.3 Revise scope of recovery as suggested by new information.

7.3.1 <u>Periodically assess progress toward recovery goals and assess recovery action priorities</u>. Annually review progress toward population and abundance criteria and recommend changes, as needed, to the Puget Sound Management Unit recovery plan. In addition, review actions, action priorities, completed actions, budget, time frames, particular successes, and feasibility.

IMPLEMENTATION SCHEDULE

Implementation schedules describe recovery action priorities, action numbers, action descriptions, duration of actions, potential or participating responsible parties, total estimated costs for the duration of the action, cost estimates for the next five years, and comments. Those actions, when accomplished, will lead to recovery of bull trout in the Puget Sound Management Unit, and ultimately to recovery of bull trout in the coterminous United States.

Parties with the authority, responsibility, or expressed interest to implement a specific recovery action are identified in the implementation schedule. Listing a responsible party does not imply that prior approval has been given, nor does it require that party to participate or expend funds. However, willing participants will benefit by demonstrating that their budget submission or funding request is for a recovery action identified in an approved recovery plan, and is therefore part of a coordinated effort to recover bull trout. In addition, section 7(a)(1) of the Endangered Species Act directs all Federal agencies to use their authorities to further the purposes of the Act by implementing programs for the conservation of threatened or endangered species.

In compliance with our Endangered and Threatened Species Listing and Recovery Priority Guidelines, Recovery Plan Preparation and Implementation Priorities (48 FR 43103), we have considered and adopted priorities and subpriorities that represent recovery goals for bull trout across their native range as well as those reflected in the individual recovery plans. We have also considered established conservation plans and the ongoing local, State and Federal planning processes to maintain consistency and integration with those efforts. Assigning priorities does not imply that some recovery actions are of low importance, as all recovery actions are important to achieve the recovery objectives. We further recognize lower priority actions may be implemented ahead of higher priority actions because of the integration of bull trout recovery efforts with these existing plans and processes, and/or the availability of funding opportunities. All recovery actions will have assigned priorities based on the following:

- Priority 1: All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

- Priority 2: All actions that must be taken to prevent a significant decline in species population or habitat quality or to prevent some other significant negative effect short of extinction.

- Priority 3: All other actions necessary to provide for full recovery.

Action Number and Action Description: Recovery actions as numbered in the recovery outline. Refer to the recovery action narrative outline for descriptions.

Action Duration: Expected number of years to complete the corresponding action. Study designs can incorporate more than one action, which when combined can reduce the time needed for action completion.

Responsible or Participating Parties: The following organizations are those with the responsibility or capability to fund, authorize, or carry out the corresponding action. Within the implementation schedule, bold type indicates the agency or agencies that have the lead role for action implementation and coordination, though not necessarily sole responsibility. Additional identified agencies or parties are considered cooperators in conservation efforts. Identified parties include the following:

Federal Agencies

ACOE	Army Corps of Engineers
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
NMFS	National Marine Fisheries Service (NOAA Fisheries)
NPS	National Park Service
NRCS	Natural Resources Conservation Service
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey, Biological Resources Division

State Agencies

WDOA	Washington State Department of Agriculture
WDOE	Washington State Department of Ecology
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WDOT	Washington State Department of Transportation

Other Governments and Participating Parties

BCM	British Columbia Ministry of Water, Land and Air Protection
BNR	Burlington Northern Railway
Cities	Cities
C	Counties
NGO	Non-governmental organizations (*e.g.*, University of Washington, People for Puget Sound, Washington Trout, Regional Salmon Enhancement Groups, The Nature Conservancy, The Trust for Public Land)
NWIFC	Northwest Indian Fisheries Commission
PSE	Puget Sound Energy
Ports	Ports (*e.g.*, Port of Seattle, Port of Tacoma, Port of Bellingham)
SRFB	Salmon Recovery Funding Board
SSPS	Shared Strategy for Puget Sound Watershed Groups
SCL	Seattle City Light
SPU	Seattle Public Utilities
TG	Tribal Governments

Cost Estimates: Cost estimates are rough approximations and are provided only for general guidance. Total costs are estimated for the duration of the action, are itemized annually for the next 5 years, and include estimates of expenditures by local, Tribal, State, and Federal governments and by private business and individuals.

An asterisk (*) in the total cost column indicates ongoing actions that are currently being implemented as part of normal agency responsibilities under existing authorities. Because these actions are not being done specifically or solely for bull trout conservation, they are not included in the cost estimates. Some of these efforts may be occurring at reduced funding levels and/or in only a small portion of the watershed.

"TBD" in the total cost column indicates that estimated costs for these actions are not determinable at this time. Input is requested to help develop reasonable cost estimates for these actions.

The symbol "‡" indicates costs are combined with or embedded within other related actions.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
1	1.1.1	Identify and improve or remove unstable or problem roads causing fine sediment delivery	25	**C**, **NPS**, **Private land owners**, SRFB, TG, **USFS**, USFWS, **WDNR**, WDFW	TBD						Costs will be partially covered by ongoing actions
1	3.2.3	Increase enforcement efforts with special emphasis on bull trout spawning and pre-spawning staging areas to eliminate illegal harvest	25	**WDFW**, TG, USFS, **USFWS**	*						
1	6.1.2	Ensure protection of the highest quality spawning and rearing habitats remaining within each core area through measures including conservation land purchases and easements	25	C, NGO, SRFB, SSPS, TG, **USFS**, **USFWS**, WDFW, **WDNR**	TBD						
2	1.1.2	Improve routine road maintenance practices affecting water quality	25	**C**, **Cities**, FHWA, **WDOT**	*						

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.

TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.

‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.1.3	Implement measures to restore natural thermal regime	25	EPA, **FERC**, **WDOE**	TBD						Costs will be partially covered by ongoing actions
2	1.1.5	Encourage the uptake of marine derived nutrients from salmon carcasses into the freshwater ecosystem	25	C, SSPS, **TG**, **USFS**, USFWS, **WDFW**	‡						Cost embedded in habitat actions and action 3.1.3
2	1.1.6	Monitor water quality and meet water quality standards for temperature, nutrient loading, dissolved oxygen, and contaminants	25	C, **EPA**, FERC, TG, USFS, **WDOE**	*						
2	1.1.7	Identify, restore, and protect groundwater and hyporheic sources	25	FERC, NGO, NRCS, TG, USGS, **WDOE**, WDFW, WDNR	TBD						

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.
TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.
‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.1.8	Reduce anthropogenic sediment and contaminant sources generated from agriculture practices	25	**C**, **NRCS**, USGS, **WDOA**, WDOE	TBD						
2	1.1.9	Reduce anthropogenic sediment sources generated from forest management	25	C, **USFS**, **WDNR**	TBD						Costs will be partially covered by ongoing actions
2	1.1.10	Reduce anthropogenic sediment and contaminant sources generated from residential development and urbanization	25	**C**, **Cities**, EPA, **WDOE**	TBD						
2	1.1.11	Maintain and improve instream flows	25	C, **Cities**, EPA, **FERC**, **WDOE**	*						
2	1.2.2	Provide adequate fish passage around diversions and dams	15	**ACOE**, FERC, **City of Bellingham**, NMFS, **PSE**, **SCL**, WDFW, USFWS	55,500	3700	3700	3700	3700	3700	Costs shared with salmon recovery

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.
TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.
‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit												
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.2.3	Identify and eliminate culvert barriers	25	**C**, **Cities**, FHWA, SRFB, **TG**, WDFW, **WDNR**, **WDOT**, **USFS**, USFWS	TBD						Total cost depends on number of culverts identified and type of action necessary
2	1.3.1	Protect and restore riparian areas	25	ACOE, **C**, **Cities**, **NRCS**, SRFB, **SSPS**, TG, **USFS**, USFWS, WDFW, **WDNR**	TBD						Costs will be partially covered by ongoing actions
2	1.3.2	Identify, evaluate, and restore overwintering habitat in mainstem rivers and tributaries	25	**ACOE, C**, **Cities**, **NRCS**, SRFB, **SSPS**, TG, USFS, USFWS, WDFW, **WDNR**	TBD						Costs will be partially covered by ongoing actions for salmon
2	1.3.3	Identify and restore foraging waters with high restoration benefit	25	**ACOE**, **C**, **Cities**, **NRCS**, SRFB, **SSPS**, **TG**, **USFS**, **USFWS**, **WDFW**, **WDNR**	TBD						Costs will be partially covered by ongoing actions for salmon

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.
TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.
‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.3.4	Reduce stream channel degradation and increase channel complexity	25	**ACOE**, **C**, Cities, FERC, **NRCS**, SRFB, SSPS, TG, **USFS**, USFWS, WDFW, WDNR,	TBD						
2	1.3.5	Practice non-intrusive flood control and flood repair activities	25	**ACOE**, **NRCS**, **C**, Cities	TBD						
2	1.3.6	Reduce development impacts on streams, floodplains, and lake shores	25	ACOE, **C**, **Cities**, SSPS	TBD						
2	1.3.9	Restore natural stream channel morphology	25	**ACOE**, **C**, Cities, FERC, **NRCS**, SSPS, TG, USFS, WDFW, WDNR,	TBD						
2	1.3.11	Protect riparian and stream channel habitat at managed and unmanaged campgrounds, trail systems, and recreational sites	25	**C**, **NPS**, **USFS**, **WDNR**	*						

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.

TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.

‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.4.1	Reduce reservoir operation impacts	25	ACOE, FERC, **PSE**, **SCL**, **SPU**	TBD						
2	1.4.2	Provide sufficient instream flow downstream from dams and diversions	25	**City of Bellingham**, ACOE, **FERC**, **PSE**, **SCL**	TBD						
2	1.5.2	Upgrade or decommission existing and potential problem roads	15	**C**, **NPS**, SRFB, TG, **USFS**, USFWS **WDNR**, WDFW,	TBD						Costs will be partially covered by ongoing actions
2	1.5.3	Minimize levels of effective impervious surface from development	25	**C**, **Cities**, FHWA, WDOE, **WDOT**	TBD						
2	1.6.2	Reduce impacts of development and transportation corridors along estuarine and marine shorelines	25	**ACOE**, **BNR**, C, Cities, FHWA, **Ports**, TG, WDOT	TBD						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.6.3	Restore or recreate intertidal foraging habitats in key areas	25	**ACOE**, **C**, Cities, FHWA, **NMFS**, **NRCS**, **Ports**, SRFB, SSPS, **TG**, **USFWS**, **WDFW**, **WDNR**, **WDOT**	TBD						
2	2.4.1	Review existing protocols for eradicating, suppressing, or managing nonnative fish populations and implement protocols where needed	2	**NPS**, USFWS, **WDFW**	*						
2	2.5.1	Determine distribution and abundance of nonnative fish (brook trout and westslope cutthroat trout) and identify overlap with bull trout	5	NGO, **NPS**, TG, **USFS**, USFWS, **WDFW**	100	20	20	20	20	20	
2	2.5.2	Evaluate brook trout impacts to migratory bull trout populations	5	**NGO**, USFWS, **USGS**, WDFW	50	10	10	10	10	10	
2	2.5.3	Experimentally remove established brook trout populations from priority streams	5	NGO, **NPS**, **USFS**, USGS, USFWS, **WDFW**	25	5	5	5	5	5	

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	3.1.2	Protect remaining bull trout strongholds and native species complexes	25	**NPS**, **SPU**, **USFS**, WDFW, WDNR	0						
2	3.1.3	Provide increased forage opportunities in freshwater.	25	NMFS, **TG**, **WDFW**	TBD						
2	3.1.4	Increase biomass of marine forage base	25	**C**, NMFS, **Ports**, **TG**, **WDFW**, **WDNR**, WDOT	*						
2	3.2.1	Evaluate the impacts of harvest on bull trout populations	25	**TG**, USFWS, **WDFW**	*						
2	3.2.2	Evaluate and minimize incidental mortality of bull trout in other fisheries	25	NMFS, **NPS**, NWIFC, **TG**, USFWS, **WDFW**	TBD						
2	3.2.5	Coordinate with British Columbia on harvest management strategies	10	**BCM**, **NPS**, USFWS, **WDFW**	*						
2	3.3.1	Monitor effects of planted hatchery fish on bull trout, especially effects related to increased competition, disease, and predation	25	NGO, NMFS, **TG**, **USFWS**, USGS, **WDFW**	*						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	3.4.1	Continue to monitor and evaluate the effects of the current minimum size limit on existing recreational bull trout fisheries	25	**WDFW**, USFWS	‡						Associated with other population monitoring actions
2	3.4.2	Identify important bull trout spawning and staging areas that may require special regulations	25	**TG**, **NPS**, **USFS**, USFWS, **WDFW**	‡						Total cost will depend on 5.2.1
2	4.1.2	Determine level of interaction between bull trout and Dolly Varden populations	5	**BCM**, NGO, **NPS**, **USFWS**, USGS, SCL, **WDFW**	100	20	20	20	20	20	
2	4.2.1	Evaluate level of gene flow among core areas	5	NGO, **USFWS**, USFS, USGS, **WDFW**	TBD						Some costs embedded within other research and monitoring actions
2	5.1.1	Design and implement a population monitoring strategy for the Puget Sound Management Unit	5	BCM, NPS, TG, USFS, **USFWS**, **WDFW**	TBD						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	5.2.1	Determine complete distribution of anadromous, fluvial, and resident bull trout and habitats used by each life stage	5	BCM, NGO, **NPS**, **TG**, **USFS**, USFWS, **WDFW**	1250	250	250	250	250	250	
2	5.2.2	Determine migratory pathways and patterns, and habitat preferences of anadromous bull trout in the Puget Sound Management Unit	5	ACOE, NGO, TG, **USFWS**, USGS, **WDFW**	750	150	150	150	150	150	A study is currently being conducted in north Puget Sound by ACOE
2	5.2.5	Determine extent of effects from contaminant exposure	10	**EPA**, NMFS, **USFWS**, USGS, **WDOE**	1000	100	100	100	100	100	
2	5.2.7	Identify key habitat features within freshwater and marine habitats	10	**NGO**, NMFS, TG, **USFWS**, **USGS**, **WDOE**, WDFW	TBD						
2	5.2.8	Monitor additional local populations to provide more accurate abundance estimates for each core area	25	**NPS**, **TG**, **USFS**, **USFWS**, **WDFW**	4500	180	180	180	180	180	Assumes two index areas per core area, cost does not include existing index areas

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	5.5.1	Develop a predictive model of suitable habitat used by juvenile and resident bull trout	4	USFS, **USFWS**	180		30	75	75		Costs shared with Olympic Peninsula Management Unit
2	6.2.1	Ensure adequate protection for bull trout at all life stages under Washington State Water Quality Standards	25	**EPA**, USFWS, **WDOE**, WDFW	*						
2	6.3.1	Ensure restrictions on recreational mineral prospecting and placer mining in bull trout habitat are effective	25	**USFS**, **WDFW**	*						
3	1.1.4	Reduce anthropogenic nutrient input	25	**C**, **NRCS**, USGS, **WDOA**, WDOE, WDNR	TBD						
3	1.2.1	Eliminate or minimize entrainment at diversions and ditches	10	C, Cities, **FERC**, **NRCS**, **PSE**, **SPU**, WDFW	4,000	400	400	400	400	400	Costs shared with salmon recovery
3	1.2.4	Identify and eliminate or modify tide gates, pump stations, and flood gates blocking access to bull trout habitat	15	**ACOE**, **C**, Cities, **NRCS**, TG, WDOA, WDFW, **WDOT**	TBD						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	1.2.5	Inform the public about the impacts of recreational barriers to migrating bull trout	2	**USFS**, **WDFW**	10	5	5				Development and distribution of educational information
3	1.3.7	Reduce transportation corridor impacts on streams	25	ACOE, **BNR**, **C**, Cities, FHWA, **USFS**, WDNR, **WDOT**	TBD						
3	1.3.8	Improve grazing practices	10	**C**, **NRCS**, **WDOA**	*						
3	1.3.10	Enhance and restore instream habitat	25	**ACOE**, **C**, Cities, FERC, NGO, NRCS, SRFB, SSPS, TG, **USFS**, **USFWS**, **WDFW**, **WDNR**	TBD						
3	1.5.1	Update and/or review local Forest Service or other watershed analyses	25	**USFS**, **WDNR**	*						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	1.6.1	Identify and remediate contaminant sites in estuarine and nearshore marine areas	25	ACOE, **C**, **Cities**, EPA, **Ports**, **WDNR**, WDFW, **WDOE**	TBD						
3	2.1.1	Review and analyze effectiveness of current fish stocking polices	2	NMFS, **TG**, USFWS, **WDFW**	*						
3	2.2.1	Review existing enforcement of current policies for preventing illegal transport and introduction of nonnative fishes	5	**TG, WDFW**	*						
3	2.3.1	Discourage unauthorized fish introductions	25	**NPS**, **TG, USFS**, **USFWS**, **WDFW**	*						Likely requires additional funding
3	2.6.1	Remove invasive nonnative plants limiting the effectiveness of riparian areas and restore with native vegetation	25	**C**, **NGO**, **NRCS**, TG, **USFS**, USFWS, WDFW, **WDNR**	TBD						
3	2.6.2	Continue control of spartina in estuarine and nearshore areas	25	**C**, **WDFW**, USFWS,	TBD						
3	3.1.1	Integrate research and monitoring results into native fish management plans and related information resources	25	**NPS**, TG, **USFS**, USFWS, **WDFW**	‡						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	3.2.4	Expand angler and public education efforts	25	NGO, **NPS**, **TG**, **USFWS**, **WDFW**	100	20	20	20	20	20	
3	4.1.1	Conduct a genetic inventory	5	NPS, TG, USFS, **USFWS**, USGS, WDFW	150	30	30	30	30	30	Study plan currently being developed by USFS
3	5.1.2	Evaluate existing recovery measures over time	25	SSPS, TG, **USFWS**, WDFW	TBD						
3	5.2.3	Conduct migrational studies for the Puget Sound Management Unit and coordinate with the Olympic Peninsula Management Unit and British Columbia	5	**BCM**, **NPS**, **SCL**, **USFWS**, USGS, WDFW	TBD						Ongoing study occurring in the Upper Skagit core area by SCL and BCM
3	5.2.4	Identify and assess complete estuarine and marine forage base for bull trout	2	**NGO**, **TG**, **USFWS**, **USGS**, **WDFW**	200	100	100				
3	5.2.6	Evaluate importance of streams with only incidental bull trout presence	5	**NGO**, **USFWS**, **USGS**, **WDFW**	TBD						
3	5.2.9	Determine actions necessary to restore spawning and rearing in potential local populations	5	NGO, **NPS**, **SPU**, **USFWS**, USGS, **WDFW**	TBD						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	5.3.1	Develop a sediment monitoring program	25	**TG**, **USFS**, **USFWS**, **WDNR**	*						
3	5.3.2	Develop a temperature monitoring program	25	**EPA,** NPS, USFWS, USFS, WDNR, **WDOE**	*						
3	5.3.3	Evaluate and improve existing forestry best management practices	25	NGO, **USFS**, TG WDFW, **WDNR**	TBD						
3	5.3.4	Evaluate and improve existing agricultural conservation practices	25	C, NGO, **NRCS**, **WDOA**, WDOE, WDFW	TBD						
3	5.3.5	Evaluate and improve existing and proposed development best management practices	25	**C**, Cities, NGO, **WDOE**, WDFW	TBD						
3	5.5.2	Investigate potential use of the upper Green River by bull trout, and investigate habitat suitability	5	**ACOE**, NGO, TG, **USFWS**, USGS, WDFW	TBD						
3	5.5.3	Investigate potential use of the upper Nisqually River by bull trout	5	NGO, **NPS**, **USFS**, USGS, **USFWS**, WDFW	TBD						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	5.6.1	Determine the life history requirements and interactions of overlapping resident and migratory bull trout populations	5	NGO, TG, **USFWS**, USGS, **WDFW**	200	40	40	40	40	40	
3	6.1.1	Coordinate bull trout recovery with other listed salmonid species recovery efforts	25	NMFS, **SSPS**, TG, **USFWS**, WDFW	*						
3	7.1.1	Generate progress reports on implementation of the bull trout recovery plan	25	NPS, SSPS, TG, USFS, **USFWS**, WDFW, WDNR	*						
3	7.3.1	Periodically assess progress toward recovery goals and assess recovery action priorities	25	NRCS, **Puget Sound Recovery Team**, SSPS, TG, USFS, **USFWS**, WDFW, WDNR, WDOE	*						
			TOTAL ESTIMATED COST		68,115						

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REFERENCES

Literature Cited

Aitkin, K.J. 1998. The importance of estuarine habitats to anadromous salmonids of the Pacific Northwest: a literature review. U.S. Fish & Wildlife Service. Lacey, Washington. 24 pp.

Armstrong, R.H. 1965. Some feeding habits of the anadromous Dolly Varden *Salvelinus malma* (Walbaum) in southeastern Alaska. Alaska Department of Fish and Game. Informational Leaflet 51. Juneau, Alaska. 27 pp.

Armstrong, R.H., and J.E. Morrow. 1980. The dolly varden charr, *Salvelinus malma*. *In* E.K. Balon, ed., Charrs salmonid fishes of the genus *Salvelinus*. W. Junk Publishers, The Hague, Netherlands.

BCMWLAP (British Columbia Ministry of Water, Land and Air Protection). 2002. Environmental indicator: fish in British Columbia.

BMSL (Battelle Marine Sciences Laboratory), Pentec Environmental, Striplin Environmental Associates, Shapiro Associates, Inc., and King County Department of Natural Resources. 2001. Reconnaissance assessment of the state of the nearshore ecosystem: eastern shore of central Puget Sound, including Vashon and Maury Islands (WRIA 8 and 9). Prepared for King County Department of Natural Resources, Seattle, Washington.

Bailey, A., H. Berry, B. Bookheim, and D. Stevens. 1998. Probability-based estimation of nearshore habitat characteristics. Pages 580-588. *In* Proceedings of Puget Sound Research Conference, March 12-13, 1998. Puget Sound Water Quality Action Team, Olympia, Washington.

Baker J. and P. Moran. 2002. Report to the Puyallup Tribal Fisheries: nuclear DNA identification of migrating bull trout captured at the Puget Sound Energy diversion dam on the White River, Washington State. Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington.

Ballerini, M. J. 1993. The Jim Creek slide: an analytical investigation. Consultant report prepared for the U.S. Forest Service, Mount Baker Ranger District, Sedro Woolley, Washington. 33 pp + appendix.

Baxter, C.V. 2002. Fish movement and assemblage dynamics in a Pacific Northwest riverscape. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Baxter, J.S., E.B. Taylor, R.H. Devlin, J. Hagen and J.D. McPhail. 1997. Evidence for natural hybridization between Dolly Varden (*Salvelinus malma*) and bull trout (*S. confluentus*) in a northcentral British Columbia watershed. Can. J. Fish. Aquat. Sci. 54:421-429.

Beauchamp, D.A., and J.J. VanTassell. 2001. Modeling seasonal trophic interactions of adfluvial bull trout in Lake Billy Chinook, Oregon. Transactions of the American Fisheries Society 130:204-216.

Beecher, H.A., E.R. Dott, and R.F. Fernau. 1988. Fish species richness and stream order in Washington State streams. Environmental Biology of Fishes 22:193-209.

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14: 797-811.

Bennie, D.T. 1999. Review of the environmental occurrence of alkylphenols and alkylphenols ethoxylates. Water Qual. Res. J. Canada. Vol 34(1):79-122.

Berge, H.B. and B.V. Mavros. 2001. King County Bull Trout Program: 2000 Bull Trout Surveys. King County Department of Natural Resources, Seattle, Washington.

Blake, S. and B. Peterson. 2002. Draft watershed characterization for WRIA 01. Whatcom County, Bellingham, Washington.

Boag, T.D. 1987. Food habits of bull char, *Salvelinus confluentus*, and rainbow trout, *Salmo gairdneri*, coexisting in a foothills stream in northern Alberta. Canadian Field Naturalist 101:56-62.

Bonar, S.A., M. Divens, and B. Bolding. 1997. Methods for sampling the distribution and abundance of bull trout/Dolly Varden. Report # RAD97-05. Washington Department of Fish and Wildlife, Olympia, Washington.

Bond, C.E. 1992. Notes on the nomenclature and distribution of the bull trout and the effects of human activity on the species. Pages 1-4. *In* Howell, P.J. and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Bonneau, J.L., and D.L. Scarnecchia. 1996. Distribution of juvenile bull trout in a thermal gradient plunge pool in Granite Creek, Idaho. Transactions of the American Fisheries Society 125:628-630.

Booth, D.B. 2000. Forest cover, impervious-surface area, and the mitigation of urbanization impacts in King County, Washington. Department of Civil and Environmental Engineering, University of Washington, Seattle, Washington. Prepared for King County Water and Land Resources Division, Seattle, Washington.

Booth, D.B., J.R. Karr, S. Schauman, S.P. Konrad, S.A. Morley, M.G. Larson, P.C. Henshaw, E.J. Nelson and S.J. Burges. 2001. Urban stream rehabilitation in the Pacific Northwest. The Washington Water Resource-The quarterly report of the Center for Urban Water Resources Management. 12(1):1-11.

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. Journal of the American Water Resources Association 38:835-845.

Bortleson, G.C., M. J. Chrzastowsji, and A.K. Helgerson. 1980. Historic changes of shoreline and wetland at eleven major deltas in the Puget Sound Region. Hydraulic Investigations Atlas HA-617, Department of the Interior, U.S. Geological Survey, Washington, D.C.

Bortleson, G.C., and D.A. Davis. 1997. Pesticides in selected small streams in the Puget Sound Basin, 1987-1995. U.S. Geological Survey, National Water-Quality Assessment Program, Washington, D.C.

Brown., L.G. 1994. November 1992. The zoogeography and life history of WA native charr. Report #94-04. Washington Department of Fish and Wildlife, Fisheries Management Division, Olympia, Washington.

Buchanan, D.M., and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 1-8. *In* W.C. MacKay, M.K. Brewin, and M. Monita, editors. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

CES (Cascade Environmental Services Inc.) 1992. Trout population survey of stream WRIA #0373, tributary to the Middle Fork Nooksack, Whatcom County, Washington. Bellingham, Washington.

CSTEE (Committee on Toxicity, Ecotoxicity and the Environment). 1999. CSTEE opinion on human and wildlife health effects of endocrine disrupting chemicals, with emphasis on wildlife and on ecotoxicology test methods. Report of the working group on endocrine disrupters of the Scientific CSTEE of DG XXIV, Consumer Policy and Consumer Health Protection.

Cacek, C.C. 1989. The relationship of mass wasting to timber harvest activities in the Lightning Creek basin, Idaho and Montana. M.S. Thesis, Eastern Washington University, Ellensburg.

Campbell, C.D. 1962. Introduction to Washington geology and resources. Washington State Department of Conservation, Division of Mines and Geology, Information Circular 22R. 44 pp.

Carl, L. 1985. Management plan for bull trout in Alberta. Pages 71-80. *In* D.D. MacDonald, ed. Proceedings of the Flathead River basin bull trout biology and population dynamics modeling information exchange. British Columbia Ministry of Environment, Fisheries Branch, Cranbrook, British Columbia.

Cavender, T.M. 1978. Taxonomy and distribution of the bull trout, (*Salvelinus confluentus*) (Suckley), from the American Northwest. California Fish and Game 64(3):139-174.

City of Seattle. 2000a. Fisheries Study of Chester Morse Lake, Masonry Pool, and Major Tributaries of the Upper Cedar River Watershed. Final Report to City of Seattle. Prepared by R2 Resource Consultants, Redmond, Washington.

City of Seattle. 2000b. Habitat Conservation Plan for the Cedar River Watershed (April 2000). Seattle, Washington.

Chamberlin, T.W., R.D. Harr, and F.H. Everest. 1991. Timber harvesting, silviculture, and watershed processes. American Fisheries Society Special Publication 19:181-205.

Clancy, C.G. 1993. Statewide fisheries investigations: Bitterroot Forest inventory. Montana Fish, Wildlife, and Parks, Job Completion Report, Project F-46-R-4, Helena, Montana.

Cleary, J.S. 2001. Increasing coho productivity in the Chilliwack River watershed. Watershed Restoration Technical Bulletin, Streamline, Volume 6 Number 1. Ministry of Forests and Watershed Restoration Program, Vancouver, British Columbia. 12 pp.

Coe, T., 2001. Nooksack River watershed riparian function assessment. Report # NNR- 2001-01. Nooksack Tribe. Deming Washington.

Coe, T., and N. Currence 2001. Restoration and monitoring of Anderson Creek. Report # NNR-2001-03. Nooksack Tribe. Deming Washington.

Collins, B. D., and A.J. Sheikh, 2002. Historical riverine dynamics and habitats of the Nooksack River. Interim report to the Nooksack Tribe.

Colpitts, G., 1997. Historical perspectives of good vs. evil: stream eugenics and the plight of Alberta's bull trout: 1900-1930. Pages 31-36 *in* W.C. Mackay, M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceedings. Bull Trout Task Force, Trout Unlimited Canada, Calgary, Alberta, Canada.

Costello, A.B., T.E. Down, S.M. Pollard, C.J. Pacas, and E.B. Taylor. 2003. The influence of history and contemporary stream hydrology on the evolution of genetic diversity within species: an examination of microsatellite DNA variation in bull tyrout, *Salvelinus confluentus* (Pisces: Salmonidae). Evolution 57:328-344.

Crane, P.A., L.W. Seeb, and J.E. Seeb. 1994. Genetic relationships among Salvelinus species inferred from allozyme data. Can. J. Fish. Aquat. Sci. 51(Suppl. 1):182-197.

Crawford, J.M. 1907. Some plain truths relative to propagation. Pacific Fisherman 5(3):9-11.

Crow, J. F., and M. Kimura. 1970. An introduction to population genetics theory. Harper and Row, New York.

Crown Pacific, Inc. 1999. Acme watershed analysis. May 1999. Hamilton, Washington.

Currence, N. 2000. Middle Fork anadromous salmonid potential upstream of the diversion dam. Nooksack Tribe. Deming Washington.

DaPaul, Inc. 1994. Warnick watershed analysis. June 1994.

Daughton, C.G., and T.A. Terns. 1999. Pharmaceutical and personal care products in the environment: agents of subtle change? Environmental health perspectives. Vol. 102, supplement 6, December 1999.

David Evans and Associates and R2 Resources Consultants. 1998a. North Fork Skykomish River 1998 stream survey-Snohomish, Washington. Prepared for USDA Forest Service, Mt. Baker-Snoqualmie National Forest, North Bend Ranger District, North Bend, Washington.

David Evans and Associates and R2 Resources Consultants. 1998b. Salmon Creek 1998 stream survey-Snohomish, Washington. Prepared for USDA Forest Service, Mt. Baker-Snoqualmie National Forest, North Bend Ranger District, North Bend, Washington.

David Evans and Associates and R2 Resources Consultants. 1998c. Trout Creek 1998 stream survey-Snohomish, Washington. Prepared for USDA Forest Service, Mt. Baker-Snoqualmie National Forest, North Bend Ranger District, North Bend, Washington.

Dean, T., Z. Ferdaña, J. White, and C. Tanner. 2000. Skagit Estuary restoration assessment, Puget Sound, Washington. Prepared for People for Puget Sound.

Donald, D.B., and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71:238-247.

Doremus, L., G. Swanaset Jr., and J. Kelly. 2003. South Fork Nooksack River water quality baseline characterization draft report. Report # NNR-03-01. Nooksack Tribe. Deming, Washington.

Dunham, J.B., and B.E. Rieman. 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-655.

Dunham, J.B., B.E. Rieman, and G. Chandler. 2003. Influence of temperature and environmental variables on the distribution of bull trout within streams at the southern margin of its range. North American Journal of Fisheries Management 23:894-904.

EVS Environment Consultants, Inc. 1999. Cherry Point screening level ecological risk assessment. EVS project no. 2/868-01.1. July 1999.

Ebbert, J.C., S.S. Embrey, R.W. Black, A.J. Tesoriero, and A.L. Haggland. 2000. Water quality in the Puget Sound Basin, Washington and British Columbia, 1996-98. U.S. Geological Survey Circular 1216.

Ebbesmeyer, C.C. and R.M. Strickland. 1995. Oyster Condition and Climate: Evidence from Willapa Bay. Publication WSG_MR 95_02, Wash. Sea Grant Prog. University of Washington, Seattle, Washington. 11 p.

Embrey, S.S., and E.L. Inkpen. 1998. Water-quality assessment of the Puget Sound Basin, Washington, nutrient transport in rivers, 1980-1993: U.S. Geological Survey Water-Resources Investigation Report 97-4270, 30 pp.

Envirosphere. 1988. Study of Skagit Dams original impacts on wildlife and fish habitat and populations. Report for Seattle City Light by Envirosphere Company, Bellevue, Washington. Excerpts available online at http:www.lowimpacthydro.org/Skagit/Salmon_history.pdf.

FERC (Federal Energy Regulatory Commisssion). 1997. Final environmental impact statement, six proposed hydroelectric projects in the Nooksack River basin, Washington. FERC/EIS-0069F. Office of Hydropower Licensing, Washington D.C. September 1997.

FERC (Federal Energy Regulatory Commission). 1998. Final environmental impact statement, eight proposed hydroelectric projects in the Skagit River basin, Washington. FERC/EIS-0083-F. Office of Hydropower Licensing, Washington, DC.

FERC (Federal Energy Regulatory Commission). 2002a. Final environmental impact statement, Warm Creek and Clearwater Creek Hydroelectric Projects, Washington. FERC/EIS - 120F. Office of Hydropower Licensing, Washington, DC.

FERC (Federal Energy Regulatory Commission). 2002b. Final environmental impact statement, Martin Creek Hydroelectric Project, Washington. FERC/EIS -134F. Office of Hydropower Licensing, Washington, DC.

FFR (Forest and Fish Report). 1999. Recommendations to the Washington Forest Practices Board submitted by a consortium of landowners, Tribes, State and Federal agencies. Unpublished report is available from the Washington Department of Natural Resources, Olympia, Washington.

Footen, B. 2000. Preliminary results of an investigation into the impacts of piscivorous predation on juvenile Chinook (*Oncorhynchus tshawytscha*) and other salmonids in Salmon and Shilshole Bays, King Co. Washington. Muckleshoot Indian Tribe. Presentation at the 2000 Lake Washington Chinook Salmon Workshop, Sponsored by King County Department of Natural Resources.

Footen, B. 2003. Piscivorous impacts on Chinook (*Oncorhynchus tshawytscha*) in the Salmon Bay estuary, the Lake Washington Ship Canal and Lake Sammamish. Muckleshoot Indian Tribe. Presentation at the 2003 Lake Washington Chinook Salmon Workshop, Sponsored by Seattle Public Utilities.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63(4): 133-143.

Franklin, I. R. 1980. Evolutionary changes in small populations. Pages 135-149. *In* M.E. Soule and B.A. Wilcox, editors. Conservation biology: An evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Fresh, K.L., Rabin, D., Simenstead C., Salo E.O., Garrison, K., and L. Matheson. 1979. Fish Ecology Studies in the Nisqually Reach Area of southern Puget Sound, Washington. Report for 1977-1978.

Frissell, C.A. 1993. Topology of extinction and endangerment of native fishes in the Pacific Northwest and California. Conservation Biology 7(2):342-354.

Frissell, C.A. 1999. An ecosystem approach to habitat conservation for bull trout: groundwater and surface water protection. Open File Report 15699. Flathead Lake Biological Station, University of Montana, Polson.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance. American Fisheries Society Special Publication 19:297-323.

Gamett, B. 1999. The history and status of fishes in the Little Lost River drainage, Idaho. Salmon-Challis National Forest, Idaho Department of Fish and Game, U.S. Bureau of Land Management, Sagewillow, Inc. May 1999 draft.

GeoEngineers 2001. North Fork Nooksack River corridor analysis. Prepared for Washington State Department of Transportation. Bellingham, Washington.

Gerking, S.D. 1998. Feeding ecology of fish. Academic Press, San Diego, California.

Glass, D., and E. Salminen. 2002. Nisqually River level 1 watershed assessment (WRIA 11). Watershed Professionals Network, Envirovision, GeoEngineers.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, a literature review. Willamette National Forest. Eugene, Oregon.

Goetz, F.A. 1994. Distribution and juvenile ecology of bull trout (*Salvelinus confluentus*) in the Cascade Mountains. M.S. Thesis, Oregon State University, Corvallis, Oregon. 173 pp.

Goetz, F. 1997. Distribution of bull trout in Cascade Mountain streams of Oregon and Washington. Pages 237 – 248. *In* Mackay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Gowan, M.1989. Boulder Creek flood potential. Technical report WA-RD 207.2. Washington State Department of Transportation. Olympia, Washington.

Greene, P.M., N. Billington, and P.D.N. Nebert. 1990. Phylogenetic relationships among members of *Salvelinus* inferred from mitochondrial DNA divergence. Can. J. Fish. Aquat. Sci. 47:984-991.

Guiney, P.D., P.M. Cook, J.M. Casselman, J.D. Fitzsimmons, H.A. Simonin, E.W. Zabel, and R.E. Peterson. 1996. Assessment of 2,3,7,8-tetracholorodibenzo-p-dioxin induced sac fry mortality in lake trout (Salvelinus namaycush) from different regions of the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 53(9):2080-2092.

Haas, A., and B. Collins. 2001. A historical analysis of habitat alterations in the Snohomish River Valley, Washington, since the mid-19th century: implications for Chinook and coho salmon. The Tulalip Tribes and Snohomish County Department of Public Works, Surface Water Management.

Haas, G.R., and J.D. McPhail. 1991. Systematics and distributions of Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in North America. Can. J. Fish. Aquat. Sci. 48:2191-2211.

Haas, G.R., and J.D. McPhail. 2001. Errors in and problems with the identification of bull trout and Dolly Varden. Pages 75-76 *in* Brewin, M.K., A.J. Paul, and M. Monita, editors. Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, Alberta.

Hanski, I.A., and M.E. Gilpin (editors). 1997. Metapopulation biology. Academic Press, San Diego, California.

Healey, C.F. 1997. Fraser Basin Ecosystem Study: Final Report: Prospects For Sustainability. Lower Fraser Eco-Research Project, Westwater Research Unit Institute for Resources and Environment, University of British Columbia, Vancouver, British Columbia.

Heg, R.T., W. Rees, and W. Dunstan. 1953. Puget Sound stream studies, progress report, July through November 1953. State of Washington, Department of Fisheries.

Hoelscher, B., and T.C. Bjornn. 1989. Habitat, density, and potential production of trout and char in Pend Oreille Lake tributaries. Project F-710R-10, Subproject III, Job No. 8. Idaho Department of Fish and Game, Boise, Idaho.

Howell, P.J., and D.V. Buchanan. 1992. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Hutchinson, I. 1988. Estuarine marsh dynamics in the Puget Trough–implications for habitat management. Pages 455-462. *In* Proceedings of the first annual meeting on Puget Sound Research. Puget Sound Water Quality Authority, Seattle, Washington.

James, P.W., and H.M. Sexauer. 1997. Spawning behavior, spawning habitat, and alternative mating strategies in an adfluvial population of bull trout. Pages 325–329. *In* Mackay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada. Calgary.

Jeanes, E., C.M. Morello, and M.H. Appy. 2003. Native char utilization, lower Chehalis River and Grays Harbor estuary, Aberdeen, Washington. Prepared for U.S. Army Corps of Engineers, Seattle District by R2 Resource Consultants, Redmond, Washington.

Johnston, J.M. 1989. Ross Lake: The fish and fisheries. Report 89-6. Washington Department of Wildlife, Fisheries Management Division. Olympia, Washington.

KCDNR (King County Department of Natural Resources). 2000. Literature review and recommended sampling protocol for bull trout in King County. Seattle, Washington.

KCDNRP (King County Department of Natural Resources and Parks). 2002. King County bull trout program: 2001 bull trout surveys, freshwater and marine nearshore. Prepared by Taylor Associates, Inc., Seattle, Washington.

KCDNR (King County Department of Natural Resources) and WSCC (Washington Conservation Commission). 2000. Habitat limiting factors and reconnaissance assessment report, Green/Duwamish and Cental Puget Sound watersheds (WRIA 9 and Vashon Island). Lacey, Washington.

Kanda, N., and F. Allendorf. 2001. Genetic population structure of bull trout from the Flathead River basin as shown by microsatellites and mitochondrial DNA markers. Transactions of the American Fisheries Society 130:92-106.

Karr, J.R., and E.W. Chu. 2000. Sustaining living rivers. Excerpt from *Hydrobiologia* 422/423:1-14.

Kimura, M., and J.F. Crow. 1963. The measurement of effective population number. Evolution 17:279-288.

Klein, R.D. 1979. Urbanization and stream quality impairment. Water Resources Bulletin 15:948-963.

Knutzen, J. 1997. Evaluation of fish entrainment potential from the Chester Morse Lake/Masonry Pool system. Prepared by Foster Wheeler Environmental Corporation, Bellevue, Washington for Seattle City Light.

Kraemer, C. 1994. Some observations on the life history and behavior of the native char, Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) of the North Puget Sound Region. (Draft report) Washington Department of Wildlife.

Kruckeberg, A. 1991. Natural history of Puget Sound Country. The University of Washington Press. 75 pp.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241:1455-1460.

Lande, R. 1995. Mutation and conservation. Conservation Biology 9:782-791.

Leary, R.F. and F.W. Allendorf. 1997. Genetic confirmation of sympatric bull trout and Dolly Varden in western Washington. Transactions of the American Fisheries Society 126:715-720.

Leathe, S.A., and P. Graham. 1982. Flathead Lake fish food habits study. Environmental Protection Agency, through Steering Committee for the Flathead River Basin Environmental Impact Study. Contract R008224-01-4 to Montana Department of Fish, Wildlife, and Parks.

Levings, C. D., and R. M. Thom. 1994. A description of the fish community of the Squamish River Estuary, British Columbia: Relative abundance, seasonal changes and feeding habits of salmonids. Canadian Fisheries Marine Service Manuscript Report 1475. 63 pp.

M.A. Whelen and Associates Ltd and TSSHRC (The Steelhead Society Habitat Restoration Corporation). 1996. Chilliwack watershed stream inventory and level 1 fish habitat assessment, late summer 1995. Prepared for Ministry of Environment Lands and Parks, Lower Mainland, Region 2, Surrey, British Columbia. November 1996.

MBTSG (The Montana Bull Trout Scientific Group). 1996a. Assessment of methods for removal of suppression of introduced fish to aid in bull trout recovery. Prepared for the Montana Bull Trout Restoration Team, Montana Fish, Wildlife, and Parks, Helena, MT. March 1996.

MBTSG (The Montana Bull Trout Scientific Group). 1996b. The role of stocking in bull trout recovery. Prepared for the Montana Bull Trout Restoration Team, Montana Fish, Wildlife, and Parks, Helena, MT. June 1996.

MBTSG (The Montana Bull Trout Scientific Group). 1998. The relationship between land management activities and habitat requirements of bull trout. Prepared for the Montana Bull Trout Restoration Team, Montana Fish, Wildlife, and Parks, Helena, MT. May 1998.

Markle, D.F. 1992. Evidence of bull trout x brook trout hybrids in Oregon. Pages 58-67. *In* P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Marks, E.L., T.G. Sebastian, R.C. Ladley, and B.E. Smith. 2002. 2001-2002 annual salmon, steelhead and char report: Puyallup River Watershed. Puyallup Tribal Fisheries, Puyallup, Washington.

Maudlin M, T. Coe, N, Currence and J. Hansen. 2002. South Fork Nooksack River Acme-Saxon reach restoration planning. Lummi Nation and Nooksack Tribe, Bellingham and Deming, Washington.

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welch. 1997. Effects of urbanization on small streams in the Puget Sound lowland ecoregion. Watershed Protection Techniques 2(4):483-494.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr and B.W. Mar. 1998. Quality indices for urbanization effects in Puget Sound Lowlands streams. Final Report for Washington Department of Ecology. Dept. of Ecology, Pub. 98-04, 229 p.

McMahon, T., A. Zale, J. Selong, and R. Barrows. 1998. Growth and survival temperature criteria for bull trout: Annual report 1998. Montana State University and U.S. Fish and Wildlife Service Bozeman Fish Technology Center. Bozeman, Montana.

McMahon, T., A. Zale, J. Selong, and R. Barrows. 1999. Growth and survival temperature criteria for bull trout: Annual report 1999 (year two). Montana State University and U.S. Fish and Wildlife Service Bozeman Fish Technology Center. Bozeman, Montana.

McPhail, J.D., and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Fisheries Management Report No. 104. Dept of Zoology, University of British Columbia, Vancouver, British Columbia.

McPhail, J.D., and C.B. Murray. 1979. The life-history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. Report to B.C. Hydro and Power Authority and Kotenay Region Fish and Wildlife. Nelson, British Columbia. 113 pp.

McPhail, J.D., and E.B. Taylor. 1995. Final report to Skagit Environmental Endowment Commission. Skagit Char Project (project 94-1). Dept of Zoology, University of British Columbia, Vancouver, British Columbia..

Meffe, G.K. and C.R. Carroll. 1994. Principles of conservation biology. Sinauer Associates, Inc. Sunderland, Massachusetts. 600 pp.

Millard, T., T.P. Rollerson, and B. Thomson. 2002. Post-logging landslide rates in the Cascade Mountains, southwestern British Columbia. Forest Research Technical Report TR-023. Vancouver Forest Region, Nanaimo, British Columbia. 21 pp.

Mongillo, P.E., and M. Hallock. 1993. Native trout and char investigations. Federal Aid project F-107-R, Segment 1. Washington Department of Wildlife, Olympia, Washington.

Morley, S.A. and J.R. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound basin. Conservation Biology 16(6):1498-1509.

Murphy, M.L. 1995. Forestry impacts on freshwater habitat of anadromous salmonids in the Pacific Northwest and Alaska- requirements for protection and restoration. NOAA Coastal Ocean Program Decision Analysis Series No. 7. NOAA Coastal Ocean Office, Silver Spring, Maryland. 156 pp.

Myrick, C.A., F.T. Barrow, J.B. Dunham, B.L. Gamett, G. Haas, J.T. Peterson, B. Rieman, L.A. Weber, and A.V. Zale. 2002. Bull trout temperature thresholds. Peer review summary prepared for U.S. Fish and Wildlife Service.

NMFS (National Marine Fisheries Service). 1991. Final rule for endangered status of Snake River sockeye salmon. November 20, 1991. Federal Register 56:58619.

NMFS (National Marine Fisheries Service). 2000. Status review of Pacific hake, Pacific cod, and walleye pollock from Puget Sound, Washington. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-44.

NCRT (Nisqually Chinook Recovery Team). 2001. Nisqually Chinook Recovery Plan, Appendix 3. What happened to native Nisqually Chinook? Rationale for considering single genetic stock in the Nisqually Basin. Nisqually River Council, Olympia, Washington.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16:4-21.

Nelson, T.C., and P.A. Caverhill. 1999. Chilliwack Lake char angler survey 1998. LGL Limited Environmental Research Associates report to B.C. Ministry of Environment, Lands and Parks, Lower Mainland Region, Fish and Wildlife Management, Surrey, British Columbia.

Nisqually EDT Work Group. 1999 (draft). Factors affecting salmon production in the Nisqually Basin: summary of an EDT analysis using fall Chinook as an indicator. Nisqually Indian Tribe.

Norecol, Dames and Moore, Inc. 1999. Final report: Environmental assessment report, Sumas Energy 2, Inc. 230 kV electric transmission line, Sumas, Washington to BC Hydro's Clayburn Substation, Abbotsford, B.C. Prepared for Sumas Energy 2, Inc., Kirkland Washington. Project No. 40992-004-310. June 30, 1999.

Norgore, M., and A.W. Anderson. 1921. Report on a biological survey of the Nooksak (sic) River during the summer of 1921. University of Washington.

Norris, L.A., H.W. Lorz and S.V. Gregory. 1991. Forest Chemicals. American Fisheries Society Special Publication 19:207-296.

PSWQA (Puget Sound Water Quality Authority). 1987. Puget Sound Environmental Atlas, Volumes 1 and 2. Prepared by Evans-Hamilton, Inc. and D. R. Systems, Inc., Seattle, Washington.

PSWQA (Puget Sound Water Quality Authority). 1988. State of the Sound 1988 report. Puget Sound Water Quality Authority, Seattle, Washington. 225 pp.

PSWQAT (Puget Sound Water Quality Action Team). 2000. 2000 Puget Sound update. Seventh report of the Puget Sound ambient monitoring program. Olympia, Washington.

Pacific International Engineering. 1999. Catch summary of anadromous trout in Commencement Bay, Tacoma, Washington. Summary of four beach seine and three townet studies and one trammel net study from 1980-1999. Prepared for the Port of Tacoma. Tacoma, Washington.

Parametrix and NRC (Natural Resources Consultants, Inc). 2000. Factors affecting Chinook populations. Background report, produced for the City of Seattle.

Pautzke, C.F. 1943. Nooksack River System. Washington Department of Game description of basin by chief biologist. Olympia, Washington.

Peak Northwest. 1986. Nooksack River basin erosion and fisheries study: Boulder, Canyon, Cornell, Howard and racehorse creeks. Prepared for Lummi Nation. Talent, Oregon.

Peterson, J., J. Dunham, P. Howell, R. Thurow, and S. Bonar. 2002. Protocol for determining bull trout presence. Western Division of the American Fisheries Society. Bethesda, Maryland.

Phillips, R.B., K.A. Pleyte, and P.E. Ihssen. 1989. Patterns of chromosomal nuclear organizer region (NOR) variation in fishes of the genus *Salvelinus*. Copeia 1989:47-53.

Pleyte, K. A., S. D. Duncan, and R. B. Phillips. 1992. Evolutionary relationships of the salmonid fish genus *Salvelinus* inferred from DNA sequences of the first internal transcribed spacer (ITS1) of ribosomal DNA. Molec. Phyl. Evol. 1:223-230.

Pratt, K.L. 1985. Habitat use and species interactions of juvenile cutthroat, *Salmo clarki*, and bull trout, *Salvelinus confluentus*, in the upper Flathead River basin. M.S. Thesis, University of Idaho, Moscow.

Pratt, K.L. 1992. A review of bull trout life history. Pages 5-9. *In* Howell, P.J. and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Pratt, K.L., and J.E. Huston. 1993. Status of bull trout (*Salvelinus confluentus*) in lake Pend Oreille and the lower Clark Fork River. Draft report. Prepared for the Washington Water Power Company, Spokane, Washington.

Quigley, T.M. and S.J. Arbelbide, technical editors. 1997. An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins: Volume III. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Quigley, T.M., R.W. Haynes and R.T. Graham, technical editors. 1996. Integrated scientific assessment for ecosystem management in the interior Columbia Basin and portions of the Klamath and Great Basins. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, Oregon.

R2 Resource Consultants. 2003. Habitat conditions of tributary reaches accessible to anadromous and adfluvial salmonids and estimated salmonid production potentials: Baker River Basin. Baker River Hydroelectric Project, FERC No. 2150, Washington. October 2003 Draft.

Rao, P.S.C., and A.G. Hornsby. 2001. Behavior of pesticides in soils and water. Soil Science Fact Sheet SL 40, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Rashin, E., C. Clishe, A. Loch, and J. Bell. 1999. Effectiveness of forest road and timber harvest best management practices with respect to sediment-related water quality impacts. Publication no. 99-317. Washington State Department of Ecology, Olympia, Washington.

Ratliff, D.E., and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10 -17. *In* P.J. Howell and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Rich, C.F., Jr. 1996. Influence of abiotic and biotic factors on occurrence of resident bull trout in fragmented habitats, western Montana. M.S. thesis, Montana State University, Bozeman, Montana.

Rieman, B.E., and F.W. Allendorf. 2001. Effective populations size and genetic conservation criteria for bull trout. North American Journal of Fisheries Management 21:756-764.

Rieman, B.E., and J.B. Dunham. 2000. Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. Ecology of Freshwater Fish 9:51-64.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. U.S. Forest Service, Intermountain Research Station. General Technical Report INT-302.

Rieman, B.E., and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124:285-296.

Rieman, B.E., and J.D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16:132-146.

Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997. Distribution, status and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17:1111-1125.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.H. Lachner, R.N. Lea and W.B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. American Fisheries Society Special Publication 12, Bethesda, Maryland.

Roos, J.F. 1959. Feeding habits of the Dolly Varden, *Salvelinus malma* (Walbaum) at Chignik, Alaska. Trans. Amer. Fish. Soc. 88(4):253-260.

Ruediger B., and B. Ruediger. 1999. The effects of highways on trout and salmon rivers and stream in the western U.S. *In* G.L. Evink, P. Garrett, and D. Zeigler, editors. Proceedings of the third international conference on wildlife ecology and transportation. September 13-16, 1999, Missoula, Montana.

STAG (Stillaguamish Technical Advisory Group). 2002. Stillaguamish Watershed - WRIA 5 salmonid habitat evaluation, version 1.02. Stillaguamish Tribe of Indians and Snohomish County Surface Water Management.

STS Heislers Creek Hydro L.P. 1994. Heislers Creek hydroelectric project, draft application for license, FERC project no. 11389. Vols. 1 and 2. March 1994.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: A review. Conservation Biology 5:18-32.

Schmitt, C., J. Schweigert, and T.P. Quinn. 1994. Anthropogenic influences on fish populations of the Georgia Basin. Pages 218-252. *In* R.C.H. Wilson, R.J.Beamish, F. Aitkens, and J. Bell, editors. Review of the Marine Environment and Biota of Strait of Georgia, Puget Sound, and Juan de Fuca Strait, Canadian Technical Report of Fisheries and Aquatic Sciences 1948. 390 pp.

Sedell, J.R., and F.H. Everest. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Draft U.S. Department of Agriculture Report, Pacific Northwest Research Station, Corvallis, Oregon.

Sedell, J.R., F.N. Leone, and W.S. Duval. 1991. Water transportation and storage of logs. American Fisheries Society Special Publication 19:325-368.

Seiler, D., S. Neuhauser, and L. Kishimoto. 2002. Washiington Department of Fish and Wildlife annual report: 2001 Skagit River wild 0+ Chinook production evaluation. Olympia, Washington.

Servos, M.R. 1999. Review of the aquatic toxicity, estrogenic responses and bioaccumulation of alkylphenol and alklyphenol polyethoxylates. Water Qual. Res. J. Canada. 34(1):123-177.

Sexauer, H.M., and P.W. James. 1997. Microhabitat use by juvenile trout in four streams located in the eastern Cascades, Washington. Pages 361-170. *In* W.C. MacKay, M.K. Brewin, and M. Monita, editors. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Shaffer, J.A. 1998. Kelp habitats of the inland waters of Western Washington. Pages 353-362. *In* Proceedings of Puget Sound Research 1998 Conference, March 12-13, 1998, Puget Sound Water Quality Action Team, Olympia, Washington.

Shared Strategy. 2002. A shared strategy for recovery of salmon in Puget Sound. Revised draft June 29, 2001, step dates revised September 25, 2002. Shared Strategy for Puget Sound, Seattle, Washington.

Shepard M.F., and R.G. Dykeman. 1977. A study of the aquatic biota and some physical parameters of Lake Washington in the vicinity of the Shuffleton Power Plant, Renton, Washington 1975-1976. Washington Cooperative Fishery Research Unit, University of Washington, Seattle, Washington.

Shepard, B., K. Pratt, and P. Graham. 1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River basin, Montana. Montana Department of Fish, Wildlife, and Parks, Kalispell, Montana. 85 pp.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364. *In* V. S. Kennedy, editors. Estuarine comparisons. Academic Press, Toronto.

Simpson, J.C., and R.L. Wallace. 1982. Fishes of Idaho. University of Idaho Press, Moscow, Idaho.

Slaney, T.L., K.D. Hyatt, T.G. Northcote, and R.J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(10):20-35.

Smith, E.V., and M.G. Anderson. 1921. A preliminary biological survey of the Skagit and Stillaguamish Rivers. University of Washington. 76 pp.

Soicher, A. 2000. Acme watershed water quality monitoring project final report. Phase I:1998-1999. Evergreen Land Trust. Van Zandt, Washington.

Soulé, M.E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-170. *In* M. E. Soulé and B. A. Wilcox, editors. Conservation biology: An evolutionary-ecological perspective. Sinauer and Associates, Sunderland, Massachusetts.

Spence, B.C., G.A. Lomnicky, R.M. Hughs, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR. (Available from the National Marine Fisheries Service, Portland, Oregon).

Spencer, C.N., and C.L. Schelske. 1998. Impact of timber harvest on sediment deposition in surface waters in Northwest Montana over the last 150 years: a paleolimnological study. Pages 187-201. *In*: M.K. Brewin and D.M. A. Monita, editors. Forest-fish conference: land management practices affecting aquatic ecosystems. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta. Nat. Can., Canada Forestry Service Northern Forestry Center, Edmonton, Alberta. Inf. Rep. NOR-X-356.

Spruell, P., and A.N. Maxwell. 2002. Genetic Analysis of Bull Trout and Dolly Varden in Washington. Report to the U.S. Fish and Wildlife Service and the Washington Department of Fish and Wildlife. Wild Trout and Salmon Genetics Lab, University of Montana, Missoula, Montana.

Spruell, P., A.R. Hemmingsen, P.J. Howell, N. Kanda, and F. Allendorf. 2003. Conservation genetics of bull trout: Geographic distribution of variation at microsatellite loci. Conservation Genetics 4:17-29.

Spruell, P., B.E. Rieman, K.L. Knudsen, F.M. Utter, and F.W. Allendorf. 1999. Genetic population structure within streams: microsatellite analysis of bull trout populations. Ecology of Freshwater Fish 8:114-121.

Staubitz, W.W., G.C. Bortleson, S.D. Semans, A.J. Tesoriero, and R.W. Black. 1997. Water-quality assessment of the Puget Sound Basin--Environmental setting and its implications for water quality and aquatic biota. U.S. Geological Survey, Water-Resources Investigations Report 97-4013. 76 pp.

Stuart, A.M., S.L. Thiesfeld, D.E. Ratliff, T.T. Fies and R.M. Hooton. 1997. Changes in management of bull trout in the Metolius River-from trash fish to trophy. Pages 59-66. *In* Mackay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Suckley and Cooper. 1860. Reports explorations and surveys, to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. Vol. XII. Book II. Thomas H. Ford, Printer, Washington.

Sullivan, K.J., K. Doughty, J.E. Caldwell, and P. Knudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. Timber/Fish/Wildlife Report No. TFW-WQ3-90-006. Washington Department of Natural Resources, Olympia, Washington.

Swain, L.G., P. Eng., and G. B. Holms. 1985. Ambient water quality objectives for the Fraser River sub-basin from Hope to Kanaka Creek: overview report. Resource Quality Section, Water Management Branch, Ministry of Environment, Vancouver, British Columbia.

Swanson, R.H., R.D. Wynes, and R.L. Rothwell. 1998. Estimating the cumulative long-term effects of forest harvests on annual water yield in Alberta. Pages 83-93. *In*: M.K. Brewin and D.M. A. Monita, editors. Forest-fish conference: land management practices affecting aquatic ecosystems. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta. Nat. Can., Canada Forestry Service Northern Forestry Center, Edmonton, Alberta. Inf. Rep. NOR-X-356.

Tacoma Public Utilities. 2001. Tacoma Water Habitat Conservation Plan, Green River Water Supply Operations and Watershed Protection. Volume 1 of 2. Prepared by Tacoma Public Utilities, Tacoma Water; R2 Resource Consultants, Inc.; Biota Pacific Environmental Sciences, Inc.; Gordon, Thomas, Honeywell, Malanca, Peterson and Daheim, P.L.L.C.; and Associated Earth Sciences Incorporated. Tacoma, Washington.

Tanner, C.D., J.R. Cordell, J. Rubey, and L.M. Tear. 2002. Restoration of freshwater intertidal habitat functions at Spencer Island, Washington. Restoration Ecology 10(3):564-576.

Taylor, E.B., S. Pollard, and D. Louie. 1999. Mitochondrial DNA variation in bull trout (*Salvelinus confluentus*) from northwestern North America: implications for zoogeography and conservation. Molecular Ecology 8:1155-1170.

Thomas, G. 1992. Status of bull trout in Montana. Report prepared for Montana Department of Fish, Wildlife, and Parks, Helena, Montana.

Thorpe, J.E. 1994. Salmonid Fishes and the Estuarine Environment. Estuaries 17(1A):76-93.

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14(1):18-30.

USACOE (U.S. Army Corps of Engineers). In prep. Bull trout in the nearshore. Seattle District, Seattle, Washington.

USACOE (U.S. Army Corps of Engineers). 2003. Summary of annual char counts at Buckley trapping facility on the White River, Washington. The last 4 years of counts are available online at <http://www.nws.usace.army.mil/PublicMenu/Doc_list.dfm?sitename=MM&pagename=FISHCOUNTS>.

USACOE (U.S. Army Corps of Engineers) and SC (Snohomish County). 2000. Stillaguamish River ecosystem restoration. Final environmental assessment.

USACOE (U.S. Army Corps of Engineers), U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. National Oceanographic and Atmospheric Administration. 1993. Commencement Bay Cumulative Impact Study: Volume 1. U.S. Army Corps of Engineers, Seattle District.

USACOE (U.S. Army Corps of Engineers) and WDFW (Washington Department of Fish and Wildlife). 2001. Draft feasibility cost sharing agreement (FCSA) Appendix A - project management plan, Puget Sound nearshore ecosystem restoration study.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of the Interior). 1994a. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. U.S. Department of Agriculture and U.S. Department of the Interior, Washington, D.C. 2 volumes and appendices.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of the Interior). 1994b. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. U.S. Department of Agriculture and U.S. Department of the Interior, Washington, D.C.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of the Interior). 1995a. Decision Notice/Decision Record Finding of No Significant Impact, Environmental Assessment for the Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). U.S. Department of Agriculture and U.S. Department of the Interior, Washington, D.C.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of the Interior). 1995b. Interim strategies for managing fish-producing watersheds in eastern Oregon and Washington, Idaho, western Montana and portions of Nevada (INFISH). U.S. Department of Agriculture and U.S. Department of the Interior,Washington, D.C.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of the Interior). 1997. Interior Columbia River Basin Ecosystem Management Project, Upper Columbia River Basin Draft Environmental Impact Statement. Volumes I - III.

USDI (U.S. Department of the Interior), U.S. Department of Commerce, and Washington Department of Natural Resources. 1996. Draft Environmental Impact Statement, Habitat Conservation Plan. Issued March 22, 1996. Olympia, Washington.

USEPA (U.S. Environmental Protection Agency). 2003. EPA region 10 guidance for Pacific Northwest State and Tribal temperature water quality standards. Final draft April 21, 2003. Seattle, Washington.

USFS (U.S. Forest Service). 1995a. South Fork Upper Stillaguamish Watershed Analysis. Darrington Ranger District, Mt. Baker-Snoqualmie National Forest.

USFS (U.S. Forest Service). 1995b. North Fork Nooksack River Watershed Analysis. Mt. Baker Ranger District, Mt. Baker-Snoqualmie National Forest.

USFS (U.S. Forest Service). 1996. Sauk River and Sauk River Forks Watershed Analysis. Darrington River Ranger District, Mt. Baker-Snoqualmie National Forest.

USFS (U.S. Forest Service). 1998. Carbon River Watershed Analysis. White River Ranger District, Mt. Baker-Snoqualmie National Forest.

USFWS (U.S. Fish and Wildlife Service). 1983a. Endangered and Threatened Species Listing and Recovery Priority Guidance. Federal Register 48(184):43098-43105.

USFWS (U.S. Fish and Wildlife Service). 1983b. Endangered and Threatened Species Listing and Recovery Priority Guidelines Correction. Federal Register 48(221):51985.

USFWS (U.S. Fish and Wildlife Service). 1998a. Biological opinion for the effects to bull trout from continued implementation of Land and Resource Management Plans and Resource Management Plans as amended by the Interim Strategy for Managing Fish-producing Watersheds in eastern Oregon and Washington, Idaho, western Montana, and Portions of Nevada (INFISH), and the Interim Strategy for Managing Anadromous Fish-producing Watersheds in eastern Oregon and Washington, Idaho, and portions of California (PACFISH). Region 1, U.S. Fish and Wildlife Service, Portland, Oregon and Region 6, U.S. Fish and Wildlife Service, Denver, Colorado.

USFWS (U.S. Fish and Wildlife Service). 1998b. Reinitiation of the biological opinion and conference opinion on the amendment of incidental take permit (PRT-812521) for the Washington State Department of Natural Resources' Habitat Conservation Plan to Include Bull Trout (*Salvelinus confluentus*) on the Permit (FWS Reference: 1-3-96-FW-594; X-Reference 1-3-9-HCP-013). Western Washington Office, U.S. Fish and Wildlife Service, Lacey, Washington.

USFWS (U.S. Fish and Wildlife Service). 2000. Biological opinion for the effects to bull trout from continued implementation of Land and Resource Management Plans and Resource Management Plans as amended by the Northwest Forest Plan Record of Decision. Region 1, U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2001. Biological and Conference Opinions for the Issuance of an Incidental Take Permit for the City of Tacoma, Tacoma Water Habitat Conservation Plan Green River Water

Supply Operations and Watershed Protection, in Pierce County, Washington. Lacey, Washington.

USFWS (U.S. Fish and Wildlife Service). 2002. Nisqually National Wildlife Refuge draft comprehensive conservation plan and environmental impact statement.

USFWS (U.S. Fish and Wildlife Service). 2004. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan, Coastal-Puget Sound Distinct Population Segment. Volume II (of II): Olympic Peninsula Management Unit. Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). In preparation. Multiple-year seasonal movement of migratory bull trout in the Wenatchee River Basin, Washington. Mid-Columbia River Fisheries Resource Office, Leavenworth, Washington.

USGS (U.S. Geological Survey). 1969. Water resources data for Washington; Part 1: surface water records. U.S. Department of the Interior, Geological Survey, Tacoma, Washington. 448 pp.

USGS (U.S. Geological Survey). 2001. Surface water and surface-water-quality records. 2001 annual data report. Available online at http://wa.water.usgs.gov/realtime/adr/stations.2001.html

USGS (U.S. Geological Survey). 2003. Water Resources Inventory Area 1 Watershed Management; introduction to the surface-water system. Available online at http://wa.water.usgs.gov/projects/wria01/sw_intro.htm

U.S. Fish Commission. 1901. Report of the Commissioner. Baker Lake, Washington. H.H. Buck, superintendent. pp. 83-84.

WDF (Washington Department of Fisheries). 1978. Middle Fork Nooksack assessment of potential salmon utilization above City of Bellingham water diversion dam. Olympia, Washington.

WDF (Washington Department of Fisheries), WDW (Washington Department of Wildlife), and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory. Washnigton Department of Fish and Wildlife, Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife), FishPro Inc., and Beak Consultants. 1997. Grandy Creek trout hatchery biological assessment. March 1997. Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 1997. Final environmental impact statement for the Wild Salmonid Policy. Washington Department of Fish and Wildlife, Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 1998. 1998 Washington salmonid stock inventory: bull trout/Dolly Varden. Olympia, Washington. 437 pp.

WDFW (Washington Department of Fish and Wildlife). 1999. Gold and Fish. Rules and regulations for mineral prospecting and placer mining in Washington State. January 1999. Publication GF-1-99. Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 2000a. Critical spawning habitat for herring, surf smelt, sand lance, and rock sole in Puget Sound, Washington. A guide for local governments and interested citizens. Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 2000b. Bull trout and Dolly Varden management plan. Fish Management Division, Fish Program, Olympia, Washington. September 2000.

WDFW (Washington Department of Fish and Wildlife). 2002. Streamnet, bullchar (Washington State bull trout and Dolly Varden distribution data layer). Olympia, Washington.

WDNR (Washington Department of Natural Resources). 1998. Hutchinson Creek watershed analysis. May 1998. Olympia, Washington.

WDOE (Washington Department of Ecology). 1999. Introduction to Washington Shoreline Management Act (RCW 90.58). Ecology Publication 99-1113. Olympia, Washington.

WDOE (Washington State Department of Ecology). 2000. Washington's Water Quality Management Plan to Control Nonpoint Source Pollution. Publication Number 99-26. Appendix A.

WDW (Washington Department of Wildlife). 1992. Draft bull trout/Dolly Varden management and recovery plan. Report No. 92-22. Fisheries Management Division, Olympia, Washington.

WFPB (Washington Forest Practices Board). 2001. Washington forest practices: rules-WAC 222 (including emergency rules), board manual (watershed manual not included), Forest Practices Act, RCW 76.09. Washington Forest Practices Board, Olympia, Washington.

WGSRO (Washington Governor’s Salmon Recovery Office). 1999. Statewide strategy to recover salmon, extinction is not an option. Olympia, Washington. September 1999.

WSCC (Washington State Conservation Commission). 1999a. Salmon habitat limiting factors final report, Water Resource Inventory Area 5, Stillaguamish watershed. Olympia, Washington.

WSCC (Washington State Conservation Commission). 1999b. Salmon habitat limiting factors report for the Puyallup River basin (Water Resource Inventory Area 10). Olympia, Washington.

WSCC (Washington State Conservation Commission). 1999c. Salmon and steelhead habitat limiting factors, Water Resource Inventory Area 11 (Nisqually River). Olympia, Washington.

WSCC (Washington State Conservation Commission). 2001. Salmon and steelhead habitat limiting factors report for the Cedar-Sammamish Basin (Water Resource Inventory Area 8). Washington Conservation Commission, Olympia, Washington.

WSCC (Washington State Conservation Commission). 2002a. Salmon and steelhead habitat limiting factors in WRIA 1, the Nooksack Basin. Lacey, Washington.

WSCC (Washington State Conservation Commission). 2002b. Salmonid habitat limiting factors analysis, Snohomish River watershed, (Water Resource Inventory Area 7). Olympia, Washington.

WSCC (Washington State Conservation Commission). 2003. Salmon and steelhead habitat limiting factors, Water Resource Inventory Areas 3 and 4, the Skagit and Samish Basins. Lacey, Washington.

Warner, E. 1996. Historical changes to littoral Lake Washington: implications for spawning and outmigrant salmonids. Muckelshoot Indian Tribe Fisheries Department. May 1996.

Watershed Sciences LLC. 2002. Aerial remote sensing surveys in the Nooksack River basin: thermal infrared and color videography: Final report to Nooksack Tribe. Corvallis, Oregon.

Watson, G., and T.W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: an investigation at hierarchical scales. North American Journal of Fisheries Management 17:237-252.

Weitkamp, D.E., and G.T. Ruggerone. 2000. Factors affecting Chinook populations, background report. Prepared by Parametrix, Inc, Natural Resources Consultants, and Cedar River Associates for City of Seattle, Washington. 224 pp.

Werdon, S.J. 2000. Jarbidge River watershed stream temperature monitoring 1999. Preliminary draft December 1, 2000. U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office, Reno, Nevada. 10 pp. + appendices.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Volume 1: Puget Sound region. Washington State Department of Fisheries. Olympia, Washington.

Williams, R.N., R.P. Evans, and D.K. Shiozawa. 1997. Mitochondrial DNA diversity in bull trout from the Columbia River basin. Pages 283-297 *in* W.C. Mackay, M.K. Brewin, and M. Monita, editors. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force, Trout Unlimited, Calgary, Alberta, Canada.

Willis, M., editor. 1973. Chechacos all, The pioneering of the Skagit. Skagit County Historical Series No. 3. Skagit County Historical Society, Mount Vernon, Washington.

Willis, M., editor 1975. Skagit Settlers, trials and triumphs, 1890-1920. Skagit County Historical Series No. 4. Skagit County Historical Society, Mount Vernon, Washington.

Wilson, M.F. 1997. Variation in salmonid life histories: patterns and perspectives. Research Paper PNW-RP-498. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 50 p.

Wiltermood Associates, Inc. 2000. Nisqually/Red Salmon Slough. Inventory and Preliminary Restoration Plan. Prepared for Nisqually Indian Tribe, Olympia, Washington.

Wydoski, R.S. and R.R. Whitney. 2003. Inland fishes of Washington, second edition. University of Washington Press, Seattle.

Wyman, K.H. 1975. Two unfished salmonid populations in Lake Chester Morse. M.S. Thesis, University of Washington, Seattle.

Yates, S. 2001. Juvenile salmon use of the Swinomish Channel. M.S. Thesis, Western Washington University, Bellingham.

Young, S. F. 1999. Microsatellite based species identification of upstream migrating char in the White River, Western Washington. Washington Department of Fish and Wildlife. Olympia, Washington.

In Literature

Anchor Environmental, L.L.C. 2002. Letter dated July 29, 2002 to Jim Muck (USFWS) submitting bull trout tissue samples from Middle Fork Nooksack River.

Ballinger, D., Pacific States Marine Fisheries Commission. 2000. Unpublished data of Lummi Nation Fisheries Department's beach seine surveys of Bellingham Bay, Lummi Bay, and Cherry Point in 1994 and 1995.

Barclay, M., Cascade Environmental Services. 1989. Trip report. Middle Fork gorge float survey. Sept. 7, 1989, conducted in association with proposed Heislers Creek Hydro project.

Baxter, C., and C. Torgerson. 2003. Peer review of the USFWS proposed critical habitat rule and draft recovery plan for bull trout.

Bodurtha, T., U.S. Fish and Wildlife Service. 1995. Memorandum dated January 16, 1995, to Shelley Spalding, regarding bull trout threats from active hydropower development in Washington.

Brenkman, S., Olympic National Park. 2003. Additions to recovery plan 13 January 2003.

Brenkman, S., and S. Corbett, Olympic National Park. 2003. Seasonal movements of threatened bull trout (*Salvelinus confluentus*) in the Hoh River basin and coastal Washington. Abstract. Northwest Scientific Association meeting 2003, Forks, Washington.

Brunner, K., U.S. Army Corps of Engineers. 1999a. Meeting notes from December 12, 1999, Minutes of Third Bull Trout Working Group Meeting. Communication from Doug Hotchkiss, Port of Seattle. Seattle District, U.S. Army Corps of Engineers.

Brunner, K., U.S. Army Corps of Engineers. 1999b. Meeting notes from November 4, 1999, Minutes of the First Bull Trout Working Group Meeting. Communication from Doug Hotchkiss, Port of Seattle. Seattle District, U.S. Army Corps of Engineers.

Chang, K., U.S. Forest Service. 2003. Annual Report of Activities, permit TE-037794-0, for the year 2002. January 27, 2003.

Connor, E., Seattle City Light, and Jesson D., British Columbia Ministry of Water, Land and Air Protection. 2002. Upper Skagit watershed native char study: research proposal to the Skagit Environmental Endowment Commission. November 2002.

Connor, E., Seattle City Light. 2003. Accounts of historic char use in lower Skagit River tributaries, and information on char use in Ross Lake tributaries.

Cook, P.M., W. Fredenberg, M. Lawonn, I.K. Loeffler, E. Andreasen, and R.E. Peterson. 1999. Early life stage toxicity of 2,3,7,8-Tetrachlorodibenso-p-dioxin (TCDD) and PCB 126 to bull trout. Abstract of draft manuscript.

Corral, M.D., City of Bellingham. 2001. Affadavit dated Dec. 21, 2001 describing observation of one of two fish successfully swimming over diversion dam.

Craig, S., U.S. Fish and Wildlife Service. 2000a. Unpublished night snorkeling data from Diablo Reservoir.

Craig, S., U.S. Fish and Wildlife Service. 2000b. Summary of reconnaissance snorkel survey, upper Carbon River, tributary of the Puyallup River, Washington.

Crown Pacific, Inc. 1995. Deer Creek 1995 debris torrent. Map with notes reflecting Nov. 29-30 debris flow initiation area and runout zone.

Downen, D., Washington Department of Fish and Wildlife. 2003. Unpublished survey data.

Doyle, J., (U.S. Forest Service), S. Zyskowski, J. Riedel, and R. Glesne (North Cascades National Park). 2000. Chilliwack River monitoring 1998-1999 progress report.

Ecotrust. 2002. Unpublished day snorkeling data from Hutchinson, Wanlick, and Maple Creeks.

Feldmann, C., Puget Sound Energy. 2002. Fax to Gwill Ging, U.S. Fish and Wildlife Service, January 30, 2002, regarding Electron fish recovery data.

Gilpin, M., University of California, San Diego. 1997. Bull trout connectivity on the Clark Fork River, letter to Shelley Spalding, Montana Department of Fish, Wildlife and Parks, Helena, Montana.

Glesne, R., National Park Service. 1993. Dolly Varden/bull trout and brook trout records for North Cascades National Park Complex.

Goetz, F., U.S. Army Corps of Engineers. 2003a. Unpublished snorkeling data in the Hoh River, Washington.

Goetz, F., U.S. Army Corps of Engineers. 2003b. Unpublished ultrasonic telemetry data from the Snohomish River basin and Puget Sound.

Greenberg, E. and M. Appy. R2 Resource Consultants, Inc. 2003. Memorandum: Bull trout study A-38 progress report, Baker River Hydroelectric Project. November 18, 2003.

Griffith, J., Stillaguamish Tribe. 2002. 2002 annual report to the USFWS, Permit Number: TE-026106-0.

Hopkins, D., U.S. Forest Service. 2002. Fish habitat surveys in Ruby Creek.

Huddle, D., Washington Department of Fish and Wildlife. 1995. Internal Washington Department of Fish and Wildlife memorandum on native char and redd observations through 1994. February 2, 1995.

Hunter, J., Washington Department of Fish and Wildlife. 2001. E-mail with attachment from Washington Department of Fish and Wildlife to Puget Sound Recovery Team. Bull trout scale data from John Sneva, Puyallup system.

Johnston, J., Washington Department of Fish and Wildlife. 2000. Internal Washington Department of Fish and Wildlife letter, August 2, 2000 regarding Boulder Creek. and char use.

Kraemer, C., Washington Department of Fish and Wildlife. 1999a. Bull trout in the Stillaguamish River system. July 1999.

Kraemer, C., Washington Department of Fish and Wildlife. 1999b. Bull trout in the Snohomish River system. July 1999.

Kraemer, C., Washington Department of Fish and Wildlife. 2001a. Draft core area description for Lower Skagit core area. July 2001.

Kraemer, C., Washington Department of Fish and Wildlife. 2001b. Draft core area description for Snohomish-Skykomish core area. December 2001.

Kraemer, C., Washington Department of Fish and Wildlife. 2001c. Draft bull trout recovery targets, Snohomish Basin. December 2001.

Kraemer, C., Washington Department of Fish and Wildlife. 2002. Unpublished floy tagging data for native char in the lower Skagit River.

Kraemer, C., Washington Department of Fish and Wildlife. 2003. Management Brief: Lower Skagit bull trout, age and growth information developed from scales collected from anadromous and fluvial char. January 2003.

Lummi Nation. 2003. Unpublished native char data from Hovander Trap, 1994-2002.

MRNP (Mount Rainier National Park). 2001. Unpublished fish survey data.

NMFS (National Marine Fisheries Service). 2000. Recovery planning guidance for technical recovery teams. September 2000 draft.

NOAA (National Oceanic and Atmospheric Administration). 2003. Endangered Species Act status of West Coast salmon and steelhead. Updated August 8, 2002.

Nooksack Tribe. 2001. Unpublished habitat data from Middle Fork Nooksack River tributaries.

Nooksack Tribe. 2002. Unpublished data on bull trout observations.

Nooksack Tribe. 2003. Memorandum from T. Coe to N. Currence, Feb. 19, 2003, on Feb. 13, 2003, snorkel survey of mainstem and lower Anderson Creek.

Paige, D., Seattle Public Utilities, Cedar Falls, Washington. 2003. Unpublished data, observations, and distribution maps of bull trout in the Chester Morse Lake system.

Pess, G. 2003. NOAA Fisheries, Northwest Fisheries Science Center. Unpublished Stillaguamish bull trout data, 1996 to 2003.

Pozarycki, S., U.S. Army Corps of Engineers. 2004. Meeting notes from Howard Hanson Dam ESA Annual Consultation Meeting on 22 April 2004, 9:30AM - 12:00PM at U.S. Fish and Wildlife Service/National Marine Fisheries Service, Lacey, Washington.

Puyallup Tribe. 2003. Unpublished data on bull trout captures during Puyallup River beach seines.

Rowse, M., National Marine Fisheries Service. 2002. Email of unpublished data sent to Fred Goetz, U.S. Army Corps of Engineers, July 2002.

Samora, B., Mount Rainier National Park. 1997. Letter to Leslie Propp, U.S. Fish and Wildlife Service, April, 1997, providing fish survey information on tributaries to the Carbon River in Mount Rainier National Park.

Samora, B., Mount Rainier National Park. 1998. Letter to Leslie Propp, U.S. Fish and Wildlife Service, February, 1998, providing 1993 and 1995 fish survey data for Mount Rainier National Park.

Shannon, J., Taylor Associates, Inc. 2001. Take permit annual report, memorandum to Western Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service, January 19, 2001.

Teskey, J., B.C. Ministry of Environment, Fish and Wildlife Management. 1986. Letter to Brady Green, U.S. Forest Service, Mt Baker Ranger District, May 5, 1986, providing fish and wildlife resource information on Tamihi Creek.

USACOE (U.S. Army Corps of Engineers). 2002. Lower Snohomish River bull trout investigations: study design for year 2002 study, migratory behavior and habitat use of sub-adult and adult bull trout in the Snohomish River estuary.

USFS (U.S. Forest Service). 1982. Unpublished stream survey data for Cripple Creek.

USFS (U.S. Forest Service). 1990. Unpublished stream survey data for Greenwater River.

USFS (U.S. Forest Service). 1991. Unpublished stream survey data for Greenwater River.

USFWS (U.S. Fish and Wildlife Service). 2003. Puget Sound Recovery Team Meeting Summary. January 16, 2003.

WDFW (Washington Department of Fish and Wildlife). 1994. South Fork Nooksack River spring Chinook fry capture study and 1994 habitat reconnaissance, and attached unpublished data.

WDFW (Washington Department of Fish and Wildlife). 2003. Unpublished Skagit River smolt trap (scoop and screw trap) data, percent char trapped by period, 1997-1999.

WDFW (Washington Department of Fish and Wildlife) and USFS (U.S. Forest Service). 2001. Nooksack basin spawn survey records.

WDFW (Washington Department of Fish and Wildlife) and USFS (U.S. Forest Service). 2002. Nooksack basin spawn survey records.

Ylitalo, G.M., J. Buzitis, M.M. Krahn, N. Scholz, and T.K. Collier, Northwest Fisheries Science Center, National Marine Fisheries Service. 2003. Is PAH exposure of adult coho salmon related to abnormal pre-spawn mortality? Abstract of presentation given at 2003 Georgia Basin/Puget Sound Research Conference, March 31-April 3, 2003, Vancouver, B.C.

Zyskowski, S., U.S. Forest Service. 1989. Glacier Creek small hydro (FERC # 0738) additional fish information dated Dec. 29, 1989.

Zyskowski, S., U.S. Forest Service. 1991. Canyon Creek Fish Summary, and unpublished snorkel data for 1989 and 1990. June 3, 1991.

Personal Communications

Ablow, E., Seattle City Light, Seattle, Washington. 2000. Conversation regarding char sightings with Dwayne Paige, Seattle City Light, North Bend, Washington.

Appy, M., R2 Resource Consultants, Redmond, Washington. 2004. Conversation clarifying survey results in Bull Trout Study A-38 Progress Report for Baker relicensing with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington. January 27.

Barclay, M., Framatome ANP, Bellingham Washington. 2003. Conversation regarding results from tissue samples collected and submitted to Dr. Gordon Haas, and native char sightings.

Barnett, H., Seattle Public Utilities, Cedar Falls, Washington. 2003. Conversation regarding unpublished data and field observations with Dwayne Paige, Seattle City Light, North Bend, Washington.

Barr, J., Nisqually Tribe, Olympia, Washington. 2003. Conversation regarding bull trout sighting at Clear Creek Hatchery with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington. January 6.

Belknap, W., Seattle Public Utilities, Cedar Falls, Washington. 2003. Conversation regarding unpublished data and field observations with Dwayne Paige, Seattle City Light, North Bend, Washington.

Berge, H., King County Department of Natural Resources and Parks, Seattle, Washington. 2003a. E-mail subject: Char in Lk Washington. January 17.

Berge, H., King County Department of Natural Resources and Parks, Seattle, Washington. 2003b. Phone conversation regarding nearshore catches of bull trout with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington. May 13.

Binkley, K., Seattle City Light, North Bend, Washington. 1997. Conversation regarding char sighting with Dwayne Paige, Seattle City Light, North Bend, Washington.

Boggs, G., Whatcom County Conservation District. 2003. Conversation regarding farm plans with Ned Currence, Nooksack Tribe, Deming, Washington.

Brenkman, S. 2001. Olympic National Park, Port Angeles, Washington. Phone conversation regarding spawning habitat in the Hoh River, Olympic National Park with Fred Goetz, U.S. Army Corps of Engineers, Seattle, Washington.

Castle, P., Washington Department of Fish and Wildlife, La Connor, Washington. 2003a. Conversation regarding bull trout habitat use in Thunder Creek with Ed Connor, Seattle City Light, Seattle, Washington.

Castle, P., Washington Department of Fish and Wildlife, La Connor, Washington. 2003b. Conversation regarding bull trout distribution in Stillaguamish and Nooksack River systems with Ned Currence, Nooksack Tribe, Deming, Washington. March 21.

Castle, P., Washington Department of Fish and Wildlife, La Connor, Washington. 2003c. Phone conversation regarding bull trout distribution in marine areas of Puget Sound with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington. June 12.

Connor, E., Seattle City Light, Seattle, Washington. 2003a. E-mail subject: local popn's in upper Skagit. January 24.

Connor, E., Seattle City Light, Seattle, Washington. 2003b. E-mail subject: Re: Prey base in Upper Skagit core area. April 2.

Connor, E., Seattle City Light, Seattle, Washington. 2003c. E-mail subject: Re: Spawning below Diablo Dam? October 17.

Connor, E., Seattle City Light, Seattle, Washington. 2003d. E-mail subject: Re: Roland Creek observation. December 31.

Currence, N., Nooksack Tribe, Deming, Washington. 2003a. E-mail subject: Whatcom & Squalicum Creek char and descriptions for review, floy tag in lower Frasier. January 22.

Currence, N., Nooksack Tribe, Deming, Washington. 2003b. E-mail subject: bull trout observation in Skookum Creek. August 5.

Currence, N., Nooksack Tribe, Deming, Washington. 2003c. E-mail subject: information about the char photo Scott Lentz forwarded this week. December 12.

Downen, M., Washington Department of Fish and Wildlife, La Connor, Washington. 2002. Conversation regarding bull trout catches in Diablo Lake with Ed Connor, Seattle City Light, Seattle, Washington.

Downen, M., Washington Department of Fish and Wildlife, La Connor, Washington. 2003a. E-mail to Curt Kraemer, subject: Sauk Escapements. February 20.

Downen, M., Washington Department of Fish and Wildlife, La Connor, Washington. 2003b. E-mail subject: Re:bull trout in the NF Stillaguamish. December 1.

Doyle, J., U.S. Forest Service, Mount Lake Terrace, Washington. 2003. E-mail subject: DV/BT Presence in Deer Cr. May 28.

Dunphy, G., Lummi Nation, Bellingham, Washington. 2002. Conversation regarding native char observations in Nooksack basin with Ned Currence, Nooksack Tribe, Deming, Washington.

Fanos, B., Department of Fisheries and Oceans, Vancouver, B.C. 2003. Conversation regarding salmon use of Chilliwack River in U.S. with Ned Currence, Nooksack Tribe, Deming, Washington. October 28.

Gamett, B., U.S. Forest Service. 2002. Telephone conversation 06/20/02 with Shelley Spalding, U.S. Fish and Wildlife Service. Subject: relationship between water temperature and bull trout distribution and abundance in the Little Lost River, Idaho.

Ging, G., U.S. Fish and Wildlife Service, Lacey, Washington. 2002a. E-mail subject: electron forebay fish salvage. November 7.

Ging, G., U.S. Fish and Wildlife Service, Lacey, Washington. 2002b. E-mail subject: bull trout mortality. November 14.

Ging, G., U.S. Fish and Wildlife Service, Lacey, Washington. 2003. Conversation regarding power canal at Electron Diversion Dam with Jeff Chan, U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey. January 6.

Glesne, R., National Park Service, North Cascades National Park, Sedro-Woolley, Washington. 2002. Conversation regarding bull trout distribution in Chilliwack River system with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington.

Glesne, R., National Park Service, North Cascades National Park, Sedro-Woolley, Washington. 2003. Conversation regarding bull trout in Diablo Lake system with Ed Connor, Seattle City Light, Seattle, Washington.

Goetz, F., U.S. Army Corps of Engineers, Seattle District, Seattle, Washington. 2002. E-mail subject: re: more running of the Skagit bull trout. November 5.

Goetz, F., U.S. Army Corps of Engineers, Seattle District, Seattle, Washington. 2003. E-mail subject: RE: Ballard ladder observation.

Green, B., U.S. Forest Service, Mt. Baker-Snoqualmie National Forest, Sedro Woolley, Washington. 2003. Conversation regarding char use and suitable habitat in Nooksack basin with Ned Currence, Nooksack Tribe, Deming, Washington.

Grizzel, J., Washington Department of Natural Resources, Sedro Woolley, Washington. 2003. Conversation regarding relative mass wasting rates in west-side North Cascades with Ned Currence, Nooksack Tribe, Deming, Washington.

Hopkins, D., U.S. Forest Service, Okanogan National Forest, Winthrop, Washington. 2002. Conversation regarding upper Skagit River char with Ed Connor, Seattle City Light, Seattle, Washington.

Huddle, D., Washington Department of Fish and Wildlife, La Connor, Washington. 2002a. Conversation on char distributions at Nooksack char mapping meeting in Mount Vernon.

Huddle, D., Washington Department of Fish and Wildlife, La Connor, Washington. 2002b. Conversation on char distributions at second Nooksack char mapping meeting in LaConner to update Streamnet.

Huddle, D., Washington Department of Fish and Wildlife, La Connor, Washington. 2003a. Conversation on char and culverts in Nooksack watershed, including Loomis Creek, with Ned Currence, Nooksack Tribe, Deming, Washington.

Huddle, D., Washington Department of Fish and Wildlife, La Connor, Washington. 2003b. Conversation regarding bull trout use in tributaries to Lake Shannon with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington. February 27.

Jesson, D., Ministry of Water, Land and Air Protection, Fish and Wildlife Science, Surrey, British Columbia. 2002a. E-mail subject: re: looking for bull trout information for the Chilliwack system. April 24.

Jesson, D., Ministry of Water, Land and Air Protection, Fish and Wildlife Science, Surrey, British Columbia. 2002b. E-mail subject: re: Chilliwack Lake. June 11.

Johnston J., Washington Department of Fish and Wildlife. 1999a. E-mail to Fred Seavey (USFWS) on native char observations in Warm and Clearwater Creeks.

Johnston, J., Washington Department of Fish and Wildlife. 1999b. Conversation regarding bull trout habitat use in Big Beaver Creek drainage with Ed Connor, Seattle City Light, Seattle, Washington.

Kamkoff, A., Lummi Nation. 2000. Conversation regarding native char in the Nooksack River system and adjacent nearshore with Martha Jensen, U.S. Fish and Wildlife Service, Lacey, Washington.

Klochak, J., Skagit System Cooperative. 2002. Conversation regarding subadult bull trout use of the Deepwater Slough Restoration site during site visit July, 2002, with Fred Goetz, U.S. Army Corps of Engineers, Seattle, Washington.

Kraemer, C., Washington Department of Fish and Wildlife, Mill Creek, Washington. 2002. Conversation regarding char observations in Nooksack basin from when he worked in the basin.

Kraemer, C., Washington Department of Fish and Wildlife, Mill Creek, Washington. 2003a. Conversation regarding char use in independent tributaries to Puget Sound and floy tag recovered in Frasier River.

Kraemer, C., Washington Department of Fish and Wildlife, Mill Creek, Washington. 2003b. E-mail subject: Comments on Puget Sound plan.

Kraemer, C., Washington Department of Fish and Wildlife, Mill Creek, Washington. 2003c. E-mail subject: RE: Samish River.

Lee, J., Whatcom County. 2003. Conversation regarding Nooksack River bull trout observations with Ned Currence, Nooksack Tribe, Deming, Washington.

Lucchetti, G., King County Department of Natural Resources, Seattle, Washington. 2002. E-mail subject: fw: closer of a problematic USFS dispersed campground.

McGrath, S., Washington Department of Fish and Wildlife. 2003. Conversation regarding native char tissue sample collection locations in South Fork Nooksack and “Pine Creek” with Ned Currence, Nooksack Tribe, Deming, Washington.

McPhail, D., University of British Columbia, Vancouver, Canada. 1999. Conversation regarding access to Ross Lake tributaries with Ed Connor, Seattle City Light, Seattle, Washington.

Molesworth, J., U.S. Forest Service, Okanogan National Forest, Winthrop, Washington. 2002. Conversation regarding fish surveys in Ruby Creek drainage with Ed Connor, Seattle City Light, Seattle, Washington.

Molesworth, J., U.S. Forest Service, Okanogan National Forest, Winthrop, Washington. 2003. Conversation regarding impacts to bull trout in Ruby Creek drainage with Ed Connor, Seattle City Light, Seattle.

Nelson, K., Tulalip Tribes, Marysville, Washington. 2003. E-mail subject: Re: Report (Stillaguamish surveys). March 31, 2003.

Nelson, T., Washington Department of Fish and Wildlife, Olympia, Washington. 2003. E-mail subject: Re: Clearwater River observation? October 31, 2003.

Nichols, R., U.S. Forest Service, Mount Baker-Snoqualmie National Forest, Sedro Woolley, Washington. 2002. Conversation regarding mass wasting history in Nooksack drainage, char use, culverts, and habitat with Ned Currence, Nooksack Tribe, Deming, Washington.

Reynolds, K., U.S. Fish and Wildlife Service, Lacey, Washington. 2003. Conversation regarding angler catches of bull trout in the lower Carbon River with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington, and photo of adult captured by B. Pearson at the confluence with Puyallup River.

Roames, R., Washington Department of Natural Resources, Sedro Woolley, Washington. 2003 Conversation regarding mass wasting and debris flow history in Nooksack watershed.

Sahlfeld, D., Washington Department of Fish and Wildlife, La Connor, Washington. 2002. Conversation on char use in Nooksack watershed during first fish mapping party at Mount Vernon.

Schuett-Hames, J., Washington Department of Ecology, Olympia. 1999. E-mail to Andrew Phay (Whatcom Conservation District) regarding native char observations for fish distribution mapping.

Schuett-Hames, D., Cooperative Monitoring and Evaluation Committee. 2003. Conversation on past salmon observations at Excelsior/Nooksack Fall Hydro facility with Ned Currence, Nooksack Tribe, Deming, Washington.

Shannon, J., Taylor Associates, Inc., Seattle. 2002. E-mail subject: Duwamish turning basin char. September 12, 2002.

Shannon, J., Taylor Associates, Inc., Seattle. 2003. Email subject: Duwamish char. May 16, 2003.

Smith, B., Puyallup Tribe. 1998. Conversation regarding native char in the Puyallup River with Leslie Propp, U.S. Fish and Wildlife Service, Lacey, Washington.

Stagner, E., U.S. Fish and Wildlife Service, Lacey. 2003. Conversation regarding bull trout observations in the Puyallup system with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington.

Toba, D., Washington Department of Fish and Wildlife. 2003. Conversation regarding a bull trout in the Samish River with Ned Currence, Nooksack Tribe, Deming, Washington. November 9.

Werdon, S., U.S. Fish and Wildlife Service, Reno, Nevada. 1998. Conversation with Sam Lohr, U.S. Fish and Wildlife Service, Boise, Idaho, concerning bull trout observed by survey teams during the *Salvelinus confluentus* Curiosity Society meeting August 4-6, 1998.

Young, S., Washington Department of Fish and Wildlife, Olympia, Washington. 2003. E-mail subject: Nooksack char. February 20.

Young, S., Washington Department of Fish and Wildlife, Olympia, Washington. 2004. E-mail regarding Troublesome Creek char samples.

Zapel, E., Northwest Hydraulics Consulting, Seattle, Washington. 2001. E-mail to Cape Powers (City of Bellingham) on observation of what appeared to be an adult bull trout repeatedly jumping at diversion dam.

Zapel, E., Northwest Hydraulics Consultants, Seattle, Washington. 2003. Conversation regarding hydraulic conditions in Middle Fork gorge, and passage.

Zyskowski, S., National Park Service, North Cascades National Park, Sedro Woolley, Washington. 2002a. Conversation on distributions during first char fish mapping meeting at Mount Vernon with Ned Currence, Nooksack Tribe, Deming, Washington.

Zyskowski, S., National Park Service, North Cascades National Park, Sedro Woolley, Washington. 2002b. E-mail regarding bull trout surveys on Diablo Lake tributaries.

Zyskowski, S., National Park Service, North Cascades National Park, Sedro Woolley, Washington. 2003a. E-mail subject: re: Chilliwack, upper Skagit, etc. writeup review.

Zyskowski, S., National Park Service, North Cascades National Park, Sedro Woolley, Washington. 2003b. Conversation on char use in Nooksack watershed, and habitat with Ned Currence, Nooksack Tribe, Deming, Washington.

Zyskowski, S., National Park Service, North Cascades National Park, Sedro Woolley, Washington. 2003c. Conversation regarding Lightning Creek snorkel surveys with Ed Connor, Seattle City Light, Seattle, Washington.

Zyskowski, S., National Park Service, North Cascades National Park, Sedro Woolley, Washington. 2003d. Conversation regarding Swift Creek surveys with Jeff Chan, U.S. Fish and Wildlife Service, Lacey, Washington.

APPENDIX 1.

State of Washington's 1998 303(d) List for the Puget Sound Management Unit (as per section 303(d) of the Clean Water Act, 33 USC 1251 *et seq*.).

(Based on the Washington Department of Ecology 303(d) List website: http://www.ecy.wa.gov/programs/wq/303d/1998/1998_by_wrias.html)

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Chilliwack Core Area		
No	Sumas River	Fecal coliform
Nooksack Core Area		
No	Anderson Creek	Fine sediment, temperature
No	Bertrand Creek	Ammonia, dissolved oxygen, fecal coliform, instream flow
Yes	Boulder Creek	Temperature
Yes	Canyon (Lake) Creek	Temperature
Yes	Canyon Creek	Temperature
Yes	Cavanaugh Creek	Temperature
Yes	Cornell Creek	Temperature
No	Deer Creek	Ammonia, dissolved oxygen, fecal coliform, pH
No	Fishtrap Creek	Dissolved oxygen, fecal coliform, instream flow
Yes	Gallop Creek	Temperature
Yes	Howard Creek	Fine sediment, temperature
No	Johnson Creek	Dissolved oxygen
No	Nooksack River	Fecal coliform, fine sediment

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Yes	Nooksack River, Middle Fork	Temperature
No	Nooksack River, South Fork.	Instream flow, temperature
Yes	Nooksack River, South Fork	Fine sediment, temperature
No	Racehorse Creek	Fine sediment, temperature
Yes	Roaring Creek	Temperature
No	Silver Creek	Dissolved oxygen, fecal coliform
Lower Skagit Core Area		
No	Day Creek	Temperature
No	Hansen Creek	Fecal coliform, fish habitat, temperature
No	Jones Creek	Temperature
No	Nookachamps Creek	Fecal coliform, temperature
No	Skagit River	Fecal coliform
No	Wiseman Creek	Temperature
No	Finney Creek	Temperature
No	Grandy Creek	Temperature
No	Jackman Creek	Temperature
Stillaguamish Core Area		
Yes	Deer Creek	Temperature
Yes	Higgins Creek	Temperature
No	Jim Creek	Fecal coliform
No	Jorgenson Slough (Church Creek)	Fecal coliform

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Yes	Little Deer Creek	Temperature
No	Pilchuck Creek	Dissolved oxygen, temperature
No	Portage Creek	Dissolved oxygen, fecal coliform, turbidity
No	Stillaguamish River	Ammonia, arsenic, metals (copper, lead, nickel), dissolved oxygen, fecal coliform, temperature
No	Stillaguamish River, North Fork	Fecal coliform
Yes	Stillaguamish River, North Fork	Temperature
No	Stillaguamish River, South Fork	Dissolved oxygen, fecal coliform, pH, temperature
Snohomish-Skykomish Core Area		
No	Allen Creek	Dissolved oxygen, fecal coliform
No	Ebey Slough	pH, fecal coliform
No	French Creek	Dissolved oxygen, fecal coliform
No	Pilchuck River	Fecal coliform, temperature
No	Quilceda Creek	Dissolved oxygen, fecal coliform
No	Skykomish River	Metals (copper, lead, silver), fecal coliform, temperature
No	Snohomish River	Various contaminants, arsenic, copper, mercury, dissolved oxygen, fecal coliform, temperature
No	Snoqualmie River	Temperature
No	Wallace River	Temperature
No	Woods Creek	Fecal coliform

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Puyallup Core Area		
No	Boise Creek	Temperature
No	Clarks Creek	Fecal coliform, pH
No	Clear Creek	Fecal coliform
Yes (potential)	Clearwater River	Temperature
Yes	Greenwater River	Temperature
No	Puyallup River	Arsenic, fecal coliform, instream flow
No	Scatter Creek	Temperature
No	South Prairie Creek	Fecal coliform, temperature
No	Voight Creek	Temperature
No	White River	Copper, mercury, fecal coliform, instream flow, pH, temperature
No	Wilkenson Creek	Copper, temperature
Samish River foraging, migration, overwintering habitat		
No	Friday Creek	Fecal coliform
No	Samish River	Fecal coliform
Lake Washington foraging, migration, overwintering habitat		
No	Bear-Evans Creeks	Fecal coliform
No	Cedar River	Fecal coliform
No	Coal Creek	Fecal coliform
No	Issaquah Creek	Fecal coliform, temperature
No	Juanita Creek	Fecal coliform
No	Kelsey Creek	Pesticides, fecal coliform
No	Laughing Jacob’s Creek	Fecal coliform

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
No	Little Bear Creek	Fecal coliform
No	May Creek	Copper, lead, zinc, fecal coliform, temperature
No	McAleer Creek	Fecal coliform
No	North Creek	Dissolved oxygen, fecal coliform
No	Sammamish Lake	Fecal coliform
No	Sammamish River	Dissolved oxygen, fecal coliform, pH, temperature
No	Swamp Creek	Dissolved oxygen, fecal coliform
No	Thorton Creek	fecal coliform
No	Tibbetts Creek	fecal coliform
No	Union Lake/Lake Washington Ship Canal	Pesticide (dieldrin)
No	Lake Washington	Fecal coliform
Lower Green River foraging, migration, overwintering habitat		
No	Duwamish Waterway and River	Various contaminants, arsenic, metals (cadmium, chromium, copper, lead, mercury, silver, zinc), PAHs, PCBs, dissolved oxygen, fecal coliform, pH
No	Green River	Fecal coliform, metals (chromium, mercury), temperature
No	Mullen Slough	Dissolved oxygen, temperature
No	Newaukum Creek	Dissolved oxygen, fecal coliform
No	Soos Creek	Fecal coliform, temperature
No	Springbrook (Mill) Creek	Dissolved oxygen, metals (cadmium, chromium, copper, mercury, zinc), fecal coliform, temperature

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Lower Nisqually River foraging, migration, overwintering habitat		
No	McAllister Creek	Dissolved oxygen, fecal coliform
No	Ohop Creek	Fecal coliform
Puget Sound marine foraging, migration, overwintering habitat		
No	Bellingham Bay (inner) and Whatcom Water Way	Numerous contaminants, copper, lead, mercury, zinc, PCBs
No	Bellingham Bay (outer)	Fecal coliform, pH
No	Lummi Bay and Hale Passage	Fecal coliform
No	Strait of Georgia	Various contaminants, cadmium, PCBs
No	Indian Slough	Dissolved oxygen, fecal coliform, temperature
No	Padilla Bay, Fidalgo Bay, and Guemes Channel	PCBs
No	Samish Bay	Fecal coliform
No	Skagit Bay and Similk Bay	Dissolved oxygen, fecal coliform
No	Port Susan	Fecal coliform
No	Penn Cove	Dissolved oxygen
No	Port Gardner and Inner Everett Harbor	Numerous contaminants, mercury, zinc, PCBs
No	Possession Sound	Numerous contaminants, metals (cadmium, copper, lead, mercury, zinc), dissolved oxygen
No	Puget Sound (central)	Various contaminants, mercury, PCBs

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
No	Elliott Bay	Various contaminants, arsenic, metals (cadmium, chromium, copper, lead, mercury, silver, zinc), PCBs
No	Puget Sound (South Central) and East Passage	Fecal coliform
No	Commencement Bay (inner)	Various contaminants, metals (lead, mercury, zinc), PCBs
No	Commencement Bay (outer)	Various contaminants, arsenic, metals (cadmium, copper, lead, mercury, silver, zinc), PCBs
No	Thea Foss Waterway	PCBs
No	Nisqually Reach	Fecal coliform

APPENDIX 2.

Table linking Recovery Actions and Reasons for Decline in the Puget Sound Management Unit.

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
1.1.1	1,2,3		X		X	X			X
1.1.2	1,2,3		X		X	X			
1.1.3	1,2,3		X	X	X	X			
1.1.4	1,2,3			X		X			
1.1.5	1,2,3			X	X	X		X	
1.1.6	1,2,3	X	X	X	X	X			
1.1.7	1,2,3		X	X	X	X			
1.1.8	1,2,3			X					
1.1.9	1,2,3		X		X				
1.1.10	1,2,3				X	X			
1.1.11	1,2,3	X		X		X			
1.2.1	4	X		X					X
1.2.2	4	X							X
1.2.3	4		X		X				X
1.2.4	4					X			X
1.2.5	4			X		X			X
1.2.6	4							X	X

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
1.3.1	1,2,3		X	X	X	X			X
1.3.2									
1.3.3	1,2,3		X	X	X	X			X
1.3.4	1,2,3			X	X	X			
1.3.5	1,2,3			X	X	X			
1.3.6	1,2,3				X	X			
1.3.7	1,2,3				X	X			
1.3.8	1,2,3			X					
1.3.9	1,2,3		X	X	X	X			
1.3.10	1,2,3		X	X	X	X			
1.3.11	1,2,3		X						
1.4.1	1,2,3,4	X							
1.4.2	1,2,3	X							
1.5.1	1,2,3		X						
1.5.2	1,2,3		X						
1.5.3	1,2,3				X	X			
1.6.1	1,2,3				X	X			
1.6.2	1,2,3				X	X			
1.6.3	1,2,3,4			X	X	X			
2.1.1	1,2,3							X	

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
2.2.1	1,2,3							X	
2.3.1	1,2,3							X	
2.4.1	1,2,3							X	
2.5.1	1,2,3							X	
2.5.2	1,2,3							X	
2.5.3	1,2,3							X	
2.6.1	1,2,3			X		X			
2.6.2	1,2,3			X		X			
3.1.1	1,2,3							X	
3.1.2	1,2,3		X	X			X	X	
3.1.3	1,2,3							X	
3.1.4	1,2,3							X	
3.2.1	1,2,3							X	
3.2.2	1,2,3							X	
3.2.3	1,2,3							X	
3.2.4	1,2,3							X	
3.2.5	1,2,3							X	
3.3.1	1,2,3							X	
3.4.1	1,2,3							X	
3.4.2	1,2,3							X	

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
4.1.1	1,2,3,4							X	
4.1.2	1,2,3							X	
4.2.1	1,2,3,4							X	X
5.1.1	1,2,3							X	
5.1.2	1,2,3	X	X	X	X	X		X	X
5.2.1	1,2,3,4							X	
5.2.2	1,2,3,4							X	
5.2.3	1,2,3,4							X	X
5.2.4	1,2,3							X	X
5.2.5	1,2,3		X	X	X	X			
5.2.6	1,2,3							X	
5.2.7	1,2,3	X	X	X	X	X		X	
5.2.8	1,2,3							X	
5.2.9	1,2,3		X			X	X	X	
5.3.1	1,2,3		X	X	X	X	X		
5.3.2	1,2,3	X	X	X					X
5.3.3	1,2,3		X						
5.3.4	1,2,3			X					
5.3.5	1,2,3				X	X			
5.5.1	1,2,3		X					X	

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
5.5.2	1,2,3	X							X
5.5.3	1,2,3	X							X
5.6.1	1,2,3							X	
6.1.1	1,2,3	X	X	X	X	X		X	X
6.1.2	1,2,3		X		X	X	X		X
6.2.1	1,2,3,4	X	X	X	X	X	X		X
6.3.1	1,2,3,4						X		
7.1.1	1,2,3,4	X	X	X	X	X	X	X	X
7.3.1	1,2,3,4	X	X	X	X	X	X	X	X

APPENDIX 3.

Effective Population Size and Recovery Planning

Effective population size provides a standardized measure of the amount of genetic variation that is likely to be transmitted between generations within a population. Effective population size is a theoretical concept that allows one to predict potential future losses of genetic variation within a population due to small population size and genetic drift. Individuals within populations with very small effective population sizes are also subject to *inbreeding depression* because most individuals within small populations share one or more immediate ancestors (parents, grandparents, etc.) after only a few generations and will be closely related.

A number of factors affect the effective population size of a species. For example, unequal sex ratios can significantly affect effective population size because male and female adults of the parent generation must each contribute 50 percent of the genes to the progeny generation regardless of their relative numbers. Hence, effective population size will be lower than the summed census number of both sexes, and will also be less than four times as large as the number of adults of the less common sex. For example, a population derived from one male and three females would have an effective population size of three; a population derived from one male and an infinite number of females would have an effective population size of four (Crow and Kimura 1970). The latter population would experience the same amount of genetic drift as a population derived from only two males and two females. Similarly, populations with high fluctuations in abundance over time (or generations) will have an effective population size that is approximated by the harmonic mean of the effective population sizes of each generation. This harmonic mean will be influenced significantly by the generation with the lowest effective population size because that generation represents the “bottleneck” through which all genetic variation in future generations must pass.

It is relatively easy to relate effective population size to theoretical losses of genetic variation in future generations and, thus, provide conservation guidelines for effective population size. Based on standardized theoretical equations (Crow and Kimura 1970), the following guidelines have been established for maintaining minimum effective population sizes for conservation purposes:

- Effective Population Size > 50 to prevent inbreeding depression and a potential decrease in viability or reproductive fitness of a population (Franklin 1980);

- Effective Population Size > 500 to minimize loss of genetic variation due to genetic drift and maintain constant genetic variance within a population resulting from a balance between loss of variance due to genetic drift and an increase in variance due to new mutations or gene migration (Franklin 1980; Soulé 1980; Lande 1988);

- Effective Population Size > 5,000 to maintain constant variance for quasi-neutral, genetic variation that can serve as a reservoir for future adaptations in response to natural selection and changing environmental conditions (Lande 1995). The rationale here is that the effective population size needs to be large enough to minimize genetic drift and the potential loss of genetic material that may confer a slight, selective advantage under existing or future environmental conditions.

In contrast to establishing conservation guidelines for effective population size, it is much more difficult to quantitatively relate the breeding structure of a species and census numbers of populations to effective population size so that the 50/500/5000 guidelines can be applied at the appropriate scale. The longevity, life histories, and structure of individual breeding units (*i.e.*, *local populations*) must be understood sufficiently to relate the number of observed adults within a particular population (and in a particular generation) to a genetic *effective number of breeders*. Conceptually, this latter quantity will be similar to effective population size in the classical, textbook sense. Second, it is necessary to understand the amount of gene flow among geographically adjacent breeding units (*e.g.*, bull trout reproducing in adjacent tributaries to a river) so that, over multiple-generation time-scales, effective breeding numbers at the local population level can be considered part of a larger *metapopulation* with respect to applying the 50/500/5000 guidelines. For example, very small amounts of gene flow may not be sufficient to increase the effective number of breeders within a given local population above effective population equal to 50. However, in a combination of such populations that experience gene flow between them, effective breeding numbers for the metapopulation may be greater than 500. In this latter situation, one would predict significant genetic variation among breeding units and comparatively small amounts of genetic variation within individual breeding units, but the combination (or metapopulation) as a whole could potentially retain significant amounts of genetic variation over time. The key to understanding the evolutionary and conservation implications of such a breeding structure is knowing whether the individual breeding units, or local populations, are completely isolated reproductively or whether some gene flow does indeed occur, thus allowing genetic material to be reintroduced if lost from a particular population.

The effective population size > 5,000 rule derived by Lande (1995) relates largely to future evolutionary potential. Hence, the scale for its application are expected, in most cases, to be much larger than the spatial and temporal scales at which one applies the “50/500" rules. For example, the effective population size > 50 and effective population size > 500 guidelines may be most applicable on time scales encompassing 1 to 5 and 5 to 50 generations, respectively: at least 2 generations are necessary to produce “inbred” individuals after a population has gone through a major population bottleneck (*i.e.*, effective population size < 50), and a substantially greater number of generations are usually necessary for genetic drift to be significant (*i.e.*, when effective population size < 500). On the other hand, the effective population size > 5,000 guideline relates to the evolutionary persistence of a species over some defined geographic area such that, if extinction does occur, recolonization from elsewhere is precluded geographically or is unlikely to occur over microevolutionary time scales (*e.g.*, 50 or more generations).

Rieman and Allendorf (2001) have performed computer simulations of bull trout populations to understand the relationship between the observed number of adults, or spawners, within a local population and effective population size. Their best estimate of effective population size is 0.5 to 1.0 times the mean number of adult fish spawning annually. This translates into maintaining between 50 and 100 spawners per year to minimize potential inbreeding effects within local populations. The spatial scale for such a local population would encompass all adult fish with approximately equal probability of interbreeding amongst themselves within a single year or generation. One would expect such a population to include very few immigrants from another population or breeding unit. Between 500 and 1,000 spawners per year would be needed to maintain genetic variation and minimize the deleterious effects of drift. The appropriate spatial for maintaining genetic variation for bull trout would be most frequently applied at the core area level.

APPENDIX 4.

Federal Legislation, Activities and Guidelines Affecting Bull Trout Recovery

Endangered Species Act. Bull trout in the coterminous United States occur on lands administered by the Federal Government (*e.g.*, Bureau of Land Management, Forest Service, and National Park Service), various State-owned properties, and private and Tribal lands. The majority of bull trout spawning and rearing habitat occurs on Federal lands. Federal agency actions that occur on Federal lands or elsewhere with Federal funds or authorization may require consultation under the Endangered Species Act (16 USC 1531 *et seq*.). These actions include U.S. Army Corps of Engineers involvement in projects such as the construction of roads and bridges, the permitting of wetland filling and dredging projects subject to section 404 of the Clean Water Act (33 USC 1251 *et seq*.), construction, maintenance, and operation of dams and hydroelectric plants; Federal Energy Regulatory Commission-licensed hydropower projects authorized under the Federal Power Act (16 USC 791a *et seq*.); Forest Service and Bureau of Land Management timber, grazing, and recreation management activities; Environmental Protection Agency-authorized discharges under the National Pollutant Discharge Elimination System of the Clean Water Act; U.S. Housing and Urban Development projects; U.S. Bureau of Reclamation projects; and National Park Service activities. Because there are various policies, directives, and regulations providing management direction to Federal agencies and opportunities to conserve bull trout, *e.g.*, roadless area conservation on Forest Service lands (66 FR 3244), we provide the following types of activities as examples.

Bull Trout Interim Conservation Guidance. The purpose of the Bull Trout Interim Conservation Guidance is to provide U.S. Fish and Wildlife Service biologists with a tool that is useful in conducting Endangered Species Act activities, including section 7 consultations, negotiating Habitat Conservation Plans that culminate in the issuance of section 10(a)(1)(B)-incidental take permits (see section 10(a)(1) discussion below), issuing recovery permits, and providing technical assistance in forest practice rule development and other interagency bull trout conservation and recovery efforts. This document is not intended to supersede any biological opinion that has been completed for Federal agency actions. Rather, it should be used as another tool to assist in consultation on those actions.

PACFISH/INFISH. Land management plans for the Bureau of Land Management and Forest Service lands within the range of bull trout have been amended by the Interim Strategy for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH; USDA and USDI 1995a) and the Interim Strategy for Managing Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada (INFISH; USDA and USDI 1995b). PACFISH, developed by the Bureau of Land Management and Forest Service, is intended to be an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat on lands administered by the two agencies that are outside the area subject to the Northwest Forest Plan. INFISH was developed by the Forest Service to provide an interim strategy for inland native fish in areas outside those where PACFISH and the Northwest Forest Plan apply. We issued a programmatic non-jeopardy biological opinion on land and resource management plans of the Bureau of Land Management and Forest Service, as amended by PACFISH and INFISH, for the Klamath and Columbia River population segments of bull trout that endorsed implementation of additional commitments made by the two agencies (USFWS 1998a). The commitments included habitat restoration and improvement; standards and guidelines of PACFISH and INFISH; evaluation of key and priority watershed networks; completion of watershed analysis and monitoring; establishing goals for long-term conservation and recovery; and conducting section 7 consultation at the watershed level. The biological opinion also identified additional actions to help ensure conservation of bull trout. Consultations for site-specific actions are continuing, as are consultations for land and resource management plans in other bull trout population segments.

In December, 1998, the regional executives for the U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service and Bureau of

Land Management chartered The Interagency Implementation Team. This Team is integral to the implementation of PACFISH and INFISH, under the direction of the regional executives, and is responsible for coordinating implementation of the biological opinions on the effects of the aquatic conservation strategies on listed salmon, steelhead and bull trout. The Team has directed the development of a PACFISH/INFISH Monitoring Task Team to develop a monitoring program for tracking implementation and effectiveness of PACFISH/INFISH.

Northwest Forest Plan. On April 13, 1994, the Secretaries of the Department of Agriculture and the Department of the Interior adopted the Northwest Forest Plan for management of late-successional forests within the range of the northern spotted owl (USDA 1994a, b). This plan contains objectives, standards, and guidelines to provide for a functional late-successional and old-growth forest ecosystem. Included in the plan is an Aquatic Conservation Strategy involving riparian reserves, key watersheds, watershed analysis, and habitat restoration. We issued a programmatic non-jeopardy biological opinion on the plan for the Coastal-Puget Sound, Columbia River, and Klamath River population segments of bull trout (USFWS 2000). The biological opinion also identified additional actions to be taken by the Federal land managers to help ensure conservation of bull trout. These actions included clearly documenting that proposed actions are consistent with the aquatic conservation strategy objectives, developing and implementing guidance for reducing effects of road management programs on bull trout, and responding quickly to mining notices on lands administered by the Bureau of Land Management in order to advise operators how to prevent adverse effects to bull trout. Consultations for site-specific actions are ongoing.

Section 10(a)(1) Permits. Permits, authorized under section 10(a)(1) of the Endangered Species Act, may be issued to carry out otherwise prohibited activities involving endangered and threatened wildlife under certain circumstances. Permits are available for scientific purposes to enhance the propagation or survival of a species and for incidental "take" (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a listed species) in connection with otherwise lawful activities. Private landowners seeking permits for incidental take offer a means of protecting bull trout habitat through the voluntary development of Habitat Conservation Plans and Safe Harbor Agreements.

Habitat Conservation Plans. Incidental take permits are required when non-Federal activities will result in "take" of threatened or endangered species. A habitat conservation plan must accompany an application for an incidental take permit. The purpose of the Habitat Conservation Planning process is to ensure there is adequate minimization and mitigation of effects from the authorized incidental take. The purpose of the incidental take permit is to authorize the incidental take of a listed species.

As one example, the Plum Creek Timber Company developed a Habitat Conservation Plan with us addressing bull trout and other native salmonids occurring on over 688,500 hectares (1.7 million acres) of corporate lands, primarily in the Columbia River basin. The majority of the land under consideration occurs in Montana (87 percent) with the remainder in Idaho and Washington. Because silvicultural activities, logging road construction and maintenance, and open range cattle grazing by the Plum Creek Timber Company may result in harm to bull trout, seven categories of conservation commitments were included in the Habitat Conservation Plan. The seven categories are: (1) road management, (2) riparian management, (3) livestock grazing, (4) land-use planning, (5) legacy management and other restoration opportunities, (6) administration and implementation measures, and (7) monitoring and adaptive management. The conservation benefits of activities in the seven categories include reducing sediment delivery to streams from roads and grazing, increasing canopy cover in riparian areas, restoring stream bank integrity and overall habitat complexity, and providing fish passage at road culverts and water diversion structures.

In Washington, the Washington Department of Natural Resources developed a Habitat Conservation Plan that was adopted on January 1, 1999. The plan covers the approximately 647,500 hectares (1.6 million acres) of forested State trust lands that lie within the range of the northern spotted owl. The Habitat

Conservation Plan contains riparian conservation strategies that were designed to protect salmonid and riparian species for lands west of the Cascade Mountains crest. It includes a streamside no-harvest buffer strategy, a minimal-harvest area for ecosystem restoration, and a low-harvest area for selective removal of single trees or groups of trees and thinning and salvage operations. In addition to riparian buffers, road management standards were developed to ensure that mass-wasting (erosion and landslides) is not artificially accelerated and that sediment delivery remains near natural levels. The Habitat Conservation Plan also includes monitoring and adaptive management components. The minimization and mitigation actions of the plan will address habitat requirements of bull trout and cumulatively will reduce the adverse effects to bull trout in comparison to previous forest management practices (USFWS 1998b).

Safe Harbor Agreements. Safe Harbor Agreements between the U.S. Fish and Wildlife Service and non-Federal landowners are another voluntary mechanism to encourage conservation of listed species and authorize incidental take permits. In general, these agreements provide (1) conservation benefits for listed species that would otherwise not occur except for the agreement, and (2) Endangered Species Act regulatory assurances to the landowner through a section 10 permit. Safe Harbor Agreements are intended for landowners who have few or no listed species (or listed species' suitable habitat) on their property, but who would be willing to manage their property in such a way that listed species may increase on their lands, as long as they are able to conduct their intended land-use activities. An example of how Safe Harbor Agreements may be used to further bull trout conservation can be found with fish passage barriers in streams. If a landowner owns a stream with a fish passage barrier that prevents access to their property by bull trout, they may be unwilling to remove the barrier, and thereby allow access by bull trout, for fear of the "take" prohibitions under section 9 of the Endangered Species Act and potential restrictions on land-use activities. Under a Safe Harbor Agreement, the landowner would agree to removal of the barrier, allow bull trout access to their property, and the landowner and U.S. Fish and Wildlife Service would negotiate other conservation measures necessary to ensure suitable bull trout habitat conditions are maintained on the property while allowing the landowner's land-use activities to occur. The landowner would receive a section 10 permit authorizing incidental take of bull trout consistent with the agreed upon conservation measures in the Safe Harbor Agreement. Safe Harbor Agreements for bull trout may be developed in the future.

Clean Water Act. The Clean Water Act (33 USC 1251 *et seq*.) provides some regulatory mechanisms for protection and restoration of water quality in waters that support bull trout. Under sections 303 and 304, states or the Environmental Protection Agency set water quality standards, which combine designated beneficial uses and criteria established to protect uses. States or the Environmental Protection Agency designate water bodies that are failing water quality standards as water quality limited under section 303(d) (*e.g.,* Appendix 1), and are required to develop management plans. Management plans include total maximum daily loads with implementation plans that define site-specific actions and timelines for meeting water quality goals (65 FR 43586). The total maximum daily loads assess and allocate all the point and nonpoint sources of pollutants within a watershed. Best management practices are used with total maximum daily loads to address nonpoint sources of pollution, such as mining, forestry, and agriculture. Regulatory authority to enforce the best management practices, however, varies among the states. The U.S. Environmental Protection Agency requests that states give higher priority to polluted waters that are sources of drinking water or support listed species, when developing total maximum daily loads and implementation plans (65 FR 43586).

In accordance with section 319 of the Clean Water Act, states also develop programs to address nonpoint sources of pollution such as agriculture, forestry, and mining. The effectiveness of controlling water pollution from these activities has been mixed. The State of Washington monitored the effectiveness of riparian prescriptions under past forest practices regulations in meeting water quality temperature criteria for streams on forest lands and concluded that regulations for stream shading were inadequate to meet criteria (Sullivan *et al.* 1990).

Northwest Power Planning Council Fish and Wildlife Program. Congress, through the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (16 USC 839), directed the Northwest Power Planning Council to develop a Fish and Wildlife Program. The program is intended to give the citizens of Idaho, Montana, Oregon, and Washington a stronger voice in the future of electricity generated by the Federal hydropower dams in the Columbia River basin and fish and wildlife affected by the dams and their operation.

One of the Northwest Power Planning Council's major responsibilities is to develop a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River basin. State, Tribal, and local governments often work closely with the Northwest Power Planning Council as it develops power and fish and wildlife plans. The Bonneville Power Administration provides funding for implementation of the Council's Fish and Wildlife Program. In 2000, the Council amended its Fish and Wildlife Program to include development of subbasin plans. Subbasin planning, beginning in 2002, is a means for identifying projects that will be funded to protect, mitigate, and enhance the Columbia River basin’s fish and wildlife resources. These plans are viewed as crucial efforts for implementing the Endangered Species Act responsibilities of the Bonneville Power Administration, U.S. Army Corps of Engineers, and the Bureau of Reclamation in the Columbia River basin.

The primary objective of subbasin planning is to develop a unifying element for implementation of the Northwest Power Planning Council's Fish and Wildlife Program. It will also assist in the implementation of Endangered Species Act recovery activities. One of the goals of the subbasin planning process is to provide specific products that can be integrated directly into the Endangered Species Act recovery planning process. We will provide specific geographic area bull trout recovery plan to the applicable subbasin planning teams that have the responsibility for developing subbasin plans.

Federal Caucus Fish and Wildlife Plan. The Federal Caucus is a group of nine Federal agencies, formed as a result of the Federal Columbia Power System Biological Opinion, that have responsibilities for natural resources affecting species listed under the Endangered Species Act. The agencies are the National Marine Fisheries Service, U.S. Fish and Wildlife Service, Bureau of Reclamation, Bonneville Power Administration, U.S. Army Corps of Engineers, Bureau of Indian Affairs, Forest Service, Bureau of Land Management, and

Environmental Protection Agency. The Federal Caucus has drafted a basinwide recovery strategy for listed anadromous fish in the Columbia River basin which addresses management of habitat, hatcheries, harvest, and hydropower. This recovery strategy, titled 'The Conservation of Columbia River Basin Fish: Final Basin-Wide Recovery Strategy,' will provide the framework for development of recovery plans for individual species and for effects determinations for actions under consultation. As recovery plans for individual species are developed following the basinwide strategy, and measures to address biological needs of all stages of the life cycle are implemented, conditions for listed aquatic species are expected to improve sufficiently to provide for their survival and recovery. The Basin-Wide Salmon Recovery Strategy concludes that restoring tributary and estuary habitat is key to recovering listed fish. Actions focus on restoring tributary (both Federal and non-Federal), mainstem, and estuary habitat.

For long-term actions, the Basin-Wide Salmon Recovery Strategy endorses the Northwest Power Planning Council strategy of conducting subbasin assessments and developing subbasin plans and prioritizing actions based on those plans. Once the assessments are complete, the Federal agencies will participate with State agencies, local governments, Tribes and stakeholders to develop subbasin plans. Draft subbasin summaries were used extensively in the preparation of the bull trout recovery plan.

While the salmon recovery framework has only recently been adopted, and thus the benefits of this recovery framework have not yet been realized, we envision significant improvements in habitat conditions for listed salmonids as recovery activities are implemented. Because bull trout often use the same areas, we expect bull trout to similarly benefit from improved habitat conditions.

U.S. Department of Agriculture. The U.S. Department of Agriculture offers landowners financial, technical, and educational assistance to implement conservation practices on privately owned land. Using this help, farmers and ranchers apply practices that reduce soil erosion, improve water quality, and enhance forest land, wetlands, grazing lands, and wildlife habitat. U.S.

Department of Agriculture assistance also helps individuals and committees restore after floods, fires, or other natural disasters.

This assistance is provided to landowners via Farm Bill programs administered by the U.S. Department of Agriculture, Farm Service Agency and the Natural Resources Conservation Service. The implementation of practices associated with these programs may improve conditions for bull trout. In particular, the Conservation Reserve Enhancement Program is targeted to areas in Oregon and Washington where other listed fish occur and may provide direct benefits to bull trout.

The Conservation Reserve Easement Program is an addition to the Conservation Reserve Program. A Conservation Reserve Enhancement Program for the State of Oregon and the State of Washington was approved October 1998, in a Memorandum of Agreements between the United States Department of Agriculture, the Commodity Credit Corporation and the states of Oregon and Washington. The Conservation Reserve Easement Program is a partnership between Federal agencies, State agencies, and private landowners. Land enrolled in this program is removed from production and grazing, under 10 to 15 year contracts. In return, landowners receive annual rental, incentive, maintenance and cost share payments.

In Washington, eligible stream designations were originally based on spawning habitat for stocks designated as critical or depressed under the 1993 Salmon and Steelhead Stock Inventory. Approximately 9,656 kilometers (6,000 miles) of eligible streams were included. Recent changes allow for the nomination of additional stream segments where riparian habitat is a significant limiting factor, and a new cap of 16,093 kilometers (10,000 miles) of eligible streams.

Other Farm Bill programs encourage farmers to convert highly erodible cropland or other environmentally sensitive acreage to native vegetative cover, provide incentives for landowners to restore function and value to degraded wetlands on a long-term or permanent basis, assist landowners with habitat restoration and management activities specifically targeting fish and wildlife (including threatened and endangered species), provide technical and financial assistance to farmers and ranchers that face threats to soil, water, and related natural resources, and support forest management practices on privately owned, nonindustrial forest lands.

APPENDIX 5.

Glossary of Technical Terms

Adaptive trait

Characteristics that improve an individual's survival and fitness.

Adfluvial bull trout

Bull trout that migrate from tributary streams to a lake or reservoir to mature (one of three migratory bull trout life history forms, the others being anadromous and fluvial forms). Adfluvial bull trout return to a tributary to spawn.

Age class

A group of individuals of a species that have the same age, *e.g.*, 1 year old, 2 year old, etc.

Aggradation/Aggrading stream

A stream that is actively building up its channel or floodplain by being supplied with more bedload than it is capable of transporting.

Alevin

A newly hatched fish still possessing a yolk sac.

Alluvial

Pertaining to or composed of silts and clays (usually) deposited by a stream or flowing water. Alluvial deposits may occur after a flood event.

Alluvial fan

A sedimentary deposit located at a topographic break such as the base of a mountain front, escarpment, or valley side, that is composed of streamflow and/or debris flow sediments and that has the shape of a fan, either fully or partially extended.

Anadromous (fish)

A fish that is born in fresh water, migrates to the ocean to grow and live as an adult, and then returns to freshwater to spawn (reproduce). Anadramous bull trout are one of three migratory bull trout life history forms, the others being adfluvial and fluvial forms.

Artificial propagation

The use of artificial procedures to spawn adult fish and raise the resulting progeny in fresh water for release into the natural environment, either directly from the hatchery or by transfer into another area.

Bedload

Sediment particles that are moved on or immediately above the stream bed, such as the larger heavier particles (gravel, boulders) rolled along the bottom; the part of the load that is not continuously in suspension.

Braided channel/Braided stream

A stream that forms an interlacing network of branching and recombining channels separated by islands and channel bars. Generally a sign of stream disequilibrium resulting from transportation of excessive rock and sediment from upstream areas and characteristic of an aggrading stream in a wide channel on a floodplain.

Bypass system (fish)

Structure in a dam that provides a route for fish to move through or around a dam without going through the turbines.

Canopy cover (of a stream)

Vegetation projecting over a stream, including crown cover (generally more that 1 meter [3.3 feet] above the water surface) and overhang cover (less than 1 meter [3.3 feet] above the water).

Channel morphology

The physical dimension, shape, form, pattern, profile, and structure of a stream channel.

Channel stability

The ability of a stream, over time and in the present climate, to transport the sediment and flows produced by its watershed in such a manner that the stream maintains its dimension, pattern, and profile without either aggrading or degrading.

Channelization

The straightening and deepening of a stream channel to permit the water to move faster, to reduce flooding, or to drain wetlands.

Char (*also* charr)

A fish belonging to the genus *Salvelinus* and related to both the trout and salmon. The bull trout, Dolly Varden trout, and the Mackinaw trout (or lake trout) are all members of the char family. Char live in the icy waters (both fresh and marine) of North America and Europe.

Complex interacting groups

Multiple local populations within a geographic area having connectivity that allows for individuals from each of these populations the opportunity to interact with one another.

Connectivity (stream)

Suitable stream conditions that allow fish and other aquatic organisms to move freely upstream and downstream. Habitat linkages that connect to other habitat areas.

Core area

The combination of core habitat (*i.e.*, habitat that could supply all elements for the long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat) constitutes the basic unit on which to gauge recovery. Core areas require both habitat and bull trout to function, and the number (replication) and characteristics of local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. In most cases, core areas are presumed to reflect the metapopulation structure of bull trout (see "metapopulation," below).

Core habitat

Habitat that encompasses spawning and rearing habitat (resident populations), with the addition of foraging, migrating, and overwintering habitat if the population includes migratory fish. Core habitat is defined as habitat that contains, or if restored would contain, all of the essential physical elements to provide for the security of and allow for the full expression of life history forms of one or more local populations of bull trout. Core habitat may include currently unoccupied habitat if that habitat contains essential elements for bull trout to persist or is deemed critical to recovery.

Core population

A group of one or more bull trout local populations that exist within core habitat.

Deposition (stream)

The settlement or accumulation of material out of the water column and onto the stream bed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.

Deposition zone/Depositional areas (stream)

Local zones within a stream where the energy of flowing water is reduced and suspended material settles out, accumulating on the streambed.

Discharge (stream)

With reference to stream flow, the quantity of water that passes a given point in a measured unit of time, such as cubic meters per second or, often, cubic feet per second.

Distinct population segment

A distinct population segment is a population subset of a vertebrate species or subspecies that meets the tests of discreteness and significance under the joint policy of the U.S. Fish and Wildlife Service and National Marine Fisheries Service (61 FR 4722). A distinct population segment designated as such under a regulatory rulemaking is a “listable entity” under the Endangered Species Act.

Distributary

A natural stream channel that branches from a trunk stream which it may or may not rejoin. It occurs typically on the surface of an alluvial fan or delta, where it may be part of a complex, fan-shaped network that distributes the discharge and sediment load of the main channel among many small distributary channels.

Effective population size

The number of breeding individuals that would give rise to the same amount of random genetic drift as the actual population, if ideal conditions held. Generally speaking, the effective population size is a measure of the number of individuals that are contributing to future generations from a genetic perspective. The effective population size is often significantly smaller than the census population size.

Entrainment

Process by which aquatic organisms are pulled through a diversion, turbine, spillway, or other device.

Extirpation

The elimination of a species from a particular local area.

Fine sediment (fines)

Sediment with particle sizes of 2.0 millimeters (0.08 inch) or less, including sand, silt, and clay.

Fish ladder

A device to help fish swim around a dam.

Floodplain

Adjacent to stream channels, areas that are typified by flat ground and are periodically submerged by floodwater.

Flow regime

The quantity, frequency and seasonal nature of water flow.

Fluvial bull trout

Bull trout that migrate from tributary streams to larger rivers to mature (one of three migratory bull trout life history forms, the others being adfluvial and anadromous forms). Fluvial bull trout migrate to tributaries to spawn.

Foraging, migration, and overwintering habitat (bull trout)

Relatively large streams and mainstem rivers, lakes or reservoirs, estuaries, and nearshore environments, where subadult and adult migratory bull trout forage, migrate, mature, or overwinter. This habitat is typically downstream from spawning and rearing habitat and contains all the physical elements to meet critical overwintering, spawning migration, and subadult and adult rearing needs. Although use of foraging, migrating, and overwintering habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat component.

Fry

Young, recently hatched fish.

Headwaters

The source of a stream. Headwater streams are the small swales, creeks, and streams that are the origin of most rivers. These small streams join together to form larger streams and rivers or run directly into larger streams and lakes.

Hooking mortality

Death of a fish from stress or injury after it is hooked and reeled in, then released back to the water.

Hybridization

Any crossing of individuals of different genetic composition, typically different species, that result in hybrid offspring.

Hyporheic zone

Area of saturated sediment and gravel beneath and beside streams and rivers where groundwater and surface water mix. Water movement is mainly in a downstream direction.

Interspecific competition

Competition for resources between two or more different species.

Legacy effects

Impacts from past activities (usually a land use) that continue to affect a stream or watershed in the present day.

Local population

A group of bull trout that spawn within a particular stream or portion of a stream system. Multiple local populations may exist within a core area. A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (*e.g.*, those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

Littoral zone

The shore of a lake to a depth of about 10 meters (33 feet).

Management unit (bull trout)

A subset of a listed entity that is defined by the U.S. Fish and Wildlife Service for administrative and management purposes, usually to manage recovery for a species that is broadly distributed and that may experience a wide range of threats and management authorities across its distribution. In the case of bull trout, the distinct population segment was further subdivided into management units based on several factors, including biological and genetic considerations, political boundaries, and ongoing conservation efforts. In some instances, management unit boundaries were modified to maximize efficiency of established watershed groups, encompass areas of common threats, or accommodate other logistic concerns. Biologically, management units are considered groupings of bull trout for which gene flow was historically or is currently possible. Management units are utilized to more effectively target specific recovery actions, but management units are not eligible for reclassification or delisting separately from the listed entity.

Mass wasting

Loss of large amounts of material in a short period of time, *i.e.*, downward movement of land mass material or landslide.

Metapopulation

There are several different models of metapopulation dynamics, but in general a metapopulation refers to a population structure in which subpopulations may be distributed across the landscape in a patchy or semi-isolated pattern, but connectivity between these subpopulations is critical for maintaining the metapopulation as a whole. In the case of bull trout, we assumed that core areas represent the functional equivalent of a metapopulation structure for bull trout, and that the local populations within these core areas are interconnected by occasional dispersal between them and therefore share some genetic characteristics.

Migratory corridor (bull trout)

Stream reaches used by bull trout to move between habitats. A section of river or stream used by fish to access upstream spawning areas or downstream lake environments. *See also* “foraging, migration, and overwintering habitat.”

Migratory life history form (bull trout)

Bull trout that migrate from spawning and rearing habitat to lakes or reservoirs (adfluvial), larger rivers (fluvial), or the ocean (anadromous) to grow and mature.

Mysid

A small, shrimp-like crustacean of the order Mysidacea. Mysids are found primarily in marine waters, but there are some freshwater forms as well.

Nonnative species

Species not indigenous to an area, such as brook trout in the western United States.

Otolith(s)

Otoliths are compact, mineralized structures suspended in the interior of the inner ear of teleost (bony) fishes. Important in orientation and locomotion, otoliths grow in concentric layers (similar to the growth rings of a tree) reflecting the daily growth of the fish and essentially record the environmental conditions encountered by the individual.

Peak flow (stream)

Greatest stream discharge recorded over a specified period of time, usually a year, but often a season.

Penstock

In a hydropower dam, the pipe that carries water from an upstream reservoir or pond downstream to the turbine generator in a power house.

Phenotype

Expressed physical, physiological, and behavioral characteristics of an organism that may be due to genetics, the environment, or an interaction of both.

Piscivorous

Describes fish that prey on other fish for food.

Potential local population

A local population that does not currently exist, but that could exist, if spawning and rearing habitat or connectivity were restored in that area, and contribute to recovery in a known or suspected unoccupied area. Alternatively, a potential local population may be a population that is suspected to exist, but that has not yet been adequately documented.

Probability of persistence

The probability (usually expressed as a percentage) that a population or subpopulation of fish will survive and be present in a specific geographic location through some future time period, usually 100 years.

Ramp (*v*. to)/Ramping

Refers to the change of river flows as the result of dam or diversion operations. How fast the facility changes (increases or decreases) the flow is known as the "ramping rate."

Recovery team (bull trout)

A team of people with technical expertise in various aspects of bull trout biology from Federal and State agencies, Tribes, private industry, and interest groups responsible for assisting in the development of the bull trout recovery plan for a given management unit.

Redd

A nest constructed by female fish of salmonid species in streambed gravels where eggs are deposited and fertilization occurs. Redds can usually be distinguished in the streambed gravel by a cleared depression, and an associated mound of gravel directly downstream.

Refounding

Reestablishment of a species into previously occupied habitat.

Resident life history form (bull trout)

Bull trout that do not migrate, but that reside in tributary streams their entire lives (one of four bull trout life history forms; the other three forms are all migratory [adfluvial, fluvial, or anadromous]).

Revetment

A facing, usually of stone or concrete, that supports an embankment.

Riparian area

Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

Riprap

A common type of streambank armoring or protection, formed of rocks of various sizes.

Salmonid

Fish of the family Salmonidae, including trout, salmon, chars, grayling, and whitefish. In general usage, the term most often refers to salmon, trout, and chars.

Scour

Concentrated erosive action by stream water, as on the outside curve of a bend; also, a place in a streambed swept clear by a swift current.

Seral stage

A developmental stage in ecological succession, not including the climax community.

Smolt

A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater environment to a saltwater environment.

Spawning and rearing habitat/streams/areas (bull trout)

Stream reaches and the associated watershed areas that provide all habitat components necessary for spawning and juvenile rearing for a local bull trout population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident or migratory fish and may also support subadults and adults from local populations of resident bull trout.

Spawning escapement

The number of adult fish from a specific population that survive spawning migrations and enter spawning grounds.

Spillway

The part of a dam that allows high water to flow (spill) over the dam.

Splash dam

A temporary or permanent structure in a stream channel that was historically used to store logs and water until sufficient water was retained from precipitation and runoff to transport the logs downstream when the splash dam was opened.

Stochastic

The term is used to describe natural events or processes that are random. Examples include environmental conditions such as rainfall, runoff, and storm events, or life-cycle events, such as survival or fecundity rates.

Stock

The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season. A group of fish belonging to the same population, spawning in a particular stream in a particular season.

Subpopulation (bull trout)

A reproductively isolated group of bull trout spawning within a particular area of a river system; the basic unit of analysis used in the initial listing of bull trout, but not used extensively in the recovery plan.

Subwatershed

Topographic perimeter of the catchment area of a stream tributary.

Suspended sediment

Solids, either organic or inorganic, found in the water column of a stream or lake. Sources of suspended sediment may be either human induced, natural, or both.

Tailrace

A channel with highly turbulent water, usually confined by concrete or riprap, in the tailwater of a reservoir. The flowing water below a dam which is released from an upstream reservoir forms the tailwater.

Take

Activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt to engage in any such conduct to a listed (Endangered Species Act) species.

Transplantation

Moving wild fish from one stream system to another without the use of artificial propagation.

Trap and haul

An operation to physically move migratory fish upstream around a barrier that does not have a fish ladder or other passage to allow spawning. Fish are generally captured in a trap and transported by truck to a release site upstream of the barrier.

Water right

Any vested or appropriation right under which a person may lawfully divert and use water. It is a real property right appurtenant to and severable from the land on or in connection with which the water is used; such water right passes as an appurtenance with a conveyance of the land by deed, lease, mortgage, will, or inheritance.

Water yield (basin yield)

The quantity of water available from a stream at a given point over a specified duration of time.

Watershed

The area of land from which rainfall (and/or snow melt) drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins or drainage areas. Ridges of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

Woody debris

Woody material such as trees and shrubs; includes all parts of a tree such as root system, bowl, and limbs. Large woody debris refers to the woody material whose smallest diameter is greater than 10 centimeters (4 inches) and whose length is greater than 1 meter (3.3 feet).

Year class (cohort)

Fish in a stock born in the same year. For example, the 1987 year class of bull trout includes all bull trout born in 1987, which would be age 1 in 1988.